**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

# Note to Reader

**Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply. EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.**

**The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, If unacceptable risks are identified, EPA will act to reduce or eliminate the risks.**

**There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.**

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

**Note:** This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket ( RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

Jack E. Housenger, Acting Director
Special Review and Reregistration Division

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

**April 26, 2000**

**MEMORANDUM**

**SUBJECT:** Malathion: Revised Occupational and Residential Exposure and Risk Assessment for the Reregistration Elegibility Decision (RED) Document.

**FROM:** Jack Arthur, Environmental Scientist
Registration Action Branch 3
Health Effects Division (7509C)

**THRU:** Steve Dapson, Branch Senior Scientist
Registration Action Branch 3
Health Effects Division (7509C)

**TO:** Paula A. Deschamp, Biologist
Reregistration Branch 2
Health Effects Division (7509C)

The revised occupational/residential exposure assessment for the HED RED Chapter for malathion is attached. The document upon which this revision is based, is dated September 16, 1999. This assessment has been revised to reflect error-only comments submitted by Jellinek, Schwartz & Connolly, Inc., in behalf of Cheminova A/S ("Comments on EPA's Risk Assessments for Malathion,", March 29, 2000). In addition, a new separate exposure and risk assessment for the USDA Boll Weevil Eradiction Program was included in the document.

**DP Barcode:** D264848

**Chemical Number:** 057701

**Reregistration Case No.:** 0248

**EPA Reg Nos:** 4-14, 4-6, 16-5, 16-50, 70-5, 70-50, 192-5, 228-4, 228-5,228-24, 228-50, 228-95, 239-8, 239-50, 270-56, 299-50, 407-6, 407-55, 572-4, 572-6, 572-21, 572-50, 572-57, 655-5, 655-12, 655-25, 655-50, 655-57, 655-95, 706-2, 769-2, 769-3, 769-5, 769-6, 769-8, 769-13, 769-25, 769-45, 769-50, 769-57, 769-80, 769-95, 802-50, 829-5, 829-6, 829-25, 829-50, 869-50, 909-57, 1015-2, 1015-6, 1015-57, 1203-2, 1270-50, 1386-6, 1386-23, 1386-57, 1440-2, 1685-3, 2217-24, 2217-50, 2217-55, 2217-57, 2393-57, 2935-25, 2935-57, 2935-81, 3342-1, 3342-2, 3342-4, 3862-3, 3862-50, 4787-46, 4787-57, 4787-95, 5481-2, 5481-3, 5481-50, 5481-55, 5481-57, 5481-82, 5481-91, 5549-57, 5887-6, 5887-50, 5905-25, 5905-40, 5905-56, 5905-80, 5905-81, 5905-91, 7122-50, 7401-1, 7401-4, 7401-7, 7401-8, 7401-5, 7401-8, 7401-14, 7401-23, 7401-50, 7401-54, 7401-56, 7401-81, 7401-95, 8329-31, 8329-57, 8329-64, 8590-55, 8660-1, 8660-5, 8660-55, 9404-50, 9688-50, 9754-10, 9779-40, 9779-46, 9779-57, 9779-59, 10088-3, 10088-12, 10088-57, 10107-2, 10107-4, 10107-6, 10107-10, 10107-24, 10107-57, 10107-91, 10163-5, 10163-25, 10163-80, 10163-95, 10370-50, 10370-57, 10404-57, 10807-57, 10827-20, 10827-57, 10827-91, 11037-50, 19713-25, 19713-50, 19713-57, 19713-95, 28293-50, 28293-57, 33912-57, 33955-6, 33955-50, 34704-2, 34704-4, 34704-5, 34704-6, 34704-10, 34704-24, 34704-25, 34704-50, 34704-55, 34704-56, 34704-57, 34704-80, 34704-81, 34704-82, 34704-95, 34911-12, 34911-28, 34911-50, 42057-57, 45385-3, 45385-50, 46515-50, 50383-50, 51036-1, 51036-25, 51036-56, 51036-81, 51036-95, 52251-40, 55460-6, 59144-50, 62575-5, 62575-25, 62575-58, 65458-37, 67223-50, 67517-55, 65458-37, 67223-50, 67760-1, 67760-6, 67760-24, 67760-25, 67760-81

**EPA MRID No.**: 43945001 (D240569)

**PHED**: Version 1.1

**MALATHION**
**OCCUPATIONAL AND RESIDENTIAL EXPOSURE CHAPTER**

## 1.1 Purpose

In this document, which is for use in EPA's development of the Malathion Reregistration Eligibility Decision Document (RED), HED presents the results of its review of the potential human health effects of occupational and residential exposure to malathion. This particular RED includes only those product formulations, agricultural and non-agricultural use sites supported by the basic producer (Cheminova) and IR-4 and listed in a 2/17/98 Agency Memorandum.

## 1.2 Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For malathion, both criteria are met.

## 1.3 Summary of Toxicity Concerns Relating to Occupational and Residential Exposures

### 1.3.1 Acute Toxicity Categories

The toxicological data base for malathion [S-1,2-bis (ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate] is adequate and will support reregistration. Table 1 summarizes the acute toxicity values and categories for technical (97%) malathion.

Table 1: Acute Toxicity Categories for Technical Malathion

| Test | Results | Toxicity Category |
|---|---|---|
| Acute Oral - Rat | $LD_{50}$ = 5400 mg/kg/day ♂<br>5700 mg/kg/day ♀ | IV |
| Acute Dermal - Rat | $LD_{50}$ = >2000 mg/kg/day ♀♂ | III |
| Acute Inhalation - Rat | $LC_{50}$ = >5.2 mg/L ♀♂ | IV |
| Primary Eye Irritation - Rabbit | Slight conjunctival irritation; cleared by 7 days | III |
| Primary Dermal Skin Irritation - Rabbit | Slight dermal irritation (PIS = 1.1) | IV |
| Dermal Sensitization - Guinea Pig | Not dermally sensitizing | -- |

Toxicity Category III for acute dermal toxicity requires an interim 12-hour reentry interval for agricultural workers under the Worker Protection Standard.

### 1.3.2 Other Endpoints of Concern

The malathion hazard identification committee report, dated December 17, 1997, indicates there are toxicological endpoints of concern for malathion. See Table 2.

Table 2: Endpoints for Assessing Occupational and Residential Risk for Malathion

| Exposure Duration/Scenario | NOAEL for use in Risk Assessment | Target MOE |
|---|---|---|
| Acute Dietary Exposure | 50 mg/kg/day<br><br>The selected NOAEL is from a rabbit developmental study where maternal toxicity (anorexia) resulted from multiple doses. | 100 |
| Short-term Dermal Exposure (1-7 days)<br><br>Intermediate-Term Dermal Exposure (1 week to several months) | 50 mg/kg/day<br><br>Since the selected NOAEL is from a 21-day dermal rabbit toxicity study, the use of a dermal absorption factor is not necessary. Effect is inhibition of plasma, RBC and brain cholinesterase activity. | 100 |
| Long-term Dermal Exposure | 4 mg/kg/day<br><br>Since the selected NOAEL is from a 2-year rat feeding study, a 10% dermal absorption factor is used to calculate a dermal equivalent dose. Effect is inhibition of plasma cholinesterase. | 100 |
| Inhalation Exposure<br>(Short-, Intermediate- and Long-term Exposure Scenarios) | 25.8 mg/kg/day<br><br>The inhalation LOAEL of 0.1 mg/L was converted to 25.8 mg/kg/day. A 100 percent inhalation absorption factor is implicit in these estimations. Effects are inhibition of plasma and RBC cholinesterase & histopathology in respiratory epithelium. | 1000<br>See details below |
| Carcinogenicity | In accordance with the EPA *Proposed Guidelines for Carcinogen Risk Assessment* (July 1999), the Cancer Assessment Review Committee at the 12-April-2000 meeting, classified malathion as **"suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential"** by all routes of exposure. | **Quantitative risk assessment for carcinogenicity is NOT required** since the Committee classified malathion as having suggestive evidence for cancer. A cancer dose-response assessment, e.g., a low dose linear extrapolation model, is not indicated for pesticides in the "suggestive"category. |
| Aggregate Assessment | The dermal and inhalation MOEs may be combined to obtain a total MOE since a common toxicological endpoint (cholinesterase inhibition) was observed. | Aggregate Risk Index (ARI) approach used |

For inhalation exposure, a LOAEL of 0.1 mg/L (i.e., 25.8 mg/kg/day) was selected. The committee recommended that an MOE of 1000 be applied to short-term, intermediate-term and chronic inhalation risk assessments.

### 1.4 Incidents Reports (Appear in separate document)

### 1.5 Summary of Use Patterns and Formulations

### 1.5.1 Occupational-Use and Homeowner-Use Products

At this time, products containing malathion are intended for both occupational and residential uses. Occupational uses include terrestrial food and feed crops, indoor food crops, terrestrial non-food crops, and general wide-area treatments for mosquito vector control. There are outdoor residential uses of malathion which include vegetable gardens, home orchards, ornamentals and lawns.

### 1.5.2 Type of pesticide/targeted pests

Malathion [S-1,2-bis (ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate] is an organophosphate insecticide. Examples of the type of pests that malathion is used to control include (but are not limited to) the following:

- Aphids, Japanese beetles, leafhoppers, spider mites, thrips, onion maggots, armyworms, weevils, spittlebugs, lygus bugs, drosphilia, grasshoppers, lacebugs, blister beetles, and whiteflies on agricultural crops (e.g., fruits and nuts, field crops, and vegetables), homeowner fruit trees, homeowner vegetable/small fruit gardens.

- Ants, aphids, cabbage worms, crickets, spider mites, Japanese beetles, grasshoppers, red banded leaf-rollers, spittle bugs, bag worms, wax scale, greenscale, tent caterpillars, ground pearls, imported fire ants, millipedes, sawbugs, and springtails on turf.

- Aphids, spider mites, lace bugs, tent caterpillars, pine needle scale, pine needle sheath miners, red-headed pine sawfly, wax scale, oak kermes on ornamentals (e.g., flowers, shade trees, shrubs, and forest trees).

- Mosquitoes for public health.

- Boll weevil (USDA Boll Weevil Eradication Program).

### 1.5.3 Formulation types and percent active ingredient

Based on a 12/97 review of OPP Reference Files System (REFS), there are active registrations for 256 products containing malathion. Malathion is formulated as a technical (91-95% ai), a dust (1-10%, an emulsifiable concentrate (3-82% ai), a ready-to-use (1.5-95% ai), a pressurized liquid (0.5-3% ai), and a wettable powder (6-50% ai). Several of the 95% liquids are intended for Ultra-Low-Volume (ULV) applications.

For the purposes of generating this Occupational/Residential Science Chapter, the exposure/risk assessment presented here is based, in part, on the sites and use patterns on representative product labels registered to the basic producer, Cheminova. When end-use product DCIs are developed (e.g., at issuance of the RED), the Registration Division should require that all end-use product labels (e.g., MAI labels, SLNs, and products subject to the generic data exemption) be amended such that they are consistent with the basic producer labels.

### 1.5.4 Registered Use sites

**Occupational-use sites.** Malathion is registered for occupational-use on terrestrial food and feed crops, indoor food crops, aquatic food crops, terrestrial non-food crops, forestry, indoor non-food,

and indoor and outdoor residential. For ease and brevity, the occupational use sites in this RED have been grouped as follows:

- **Agricultural Crops,** including vegetables, field crops, and fruit and nut crops. Examples of these crops include, but are not limited to alfalfa, almond, anise, apple, avocado, barley, beans, beets, broccoli, cabbage, celery, chestnuts, cherries, corn, cranberry, eggplant, fig, gooseberries, grapefruit, grapes, lentils, lettuce, lemon, lime, melons, nectarines, mushrooms, oats, onions, peas, pecans, pineapples, rye, squash, strawberries, wheat, and walnut.

- **Turf**, including turf in parks, pastures, sod farms, and golf courses.

- **ULV Agricultural Crops**, including the aforementioned crops sprayed in ultra low volume over large land areas.

- **Ornamentals,** including flowers, shrubs, flowering plants, nursery stock, and woody plants.

- **Pine Trees,** including pine seed orchards, Christmas tree plantations, slash pine plantations, shrubs, shade trees, and forest trees.

- **Mosquitoes,** including fruit flies, and other swarming flying insects sprayed/fogged over large land areas.

- **ULV Mosquitoes**, including flies, and other swarming flying insects sprayed/fogged in ultra low volumes over large land areas.

- **Grape Root Dip**, including the process of dipping grape roots.

- **Storage Grain Facility**, including stored commodities such as corn, wheat, barley, oats, and rye.

- **Berries,** including blackberries, raspberries, boysenberry, dewberry, and loganberry.

- **Agricultural Premises,** including agricultural premises outside barns, applied as a bait only.

- **Mushrooms,** including mushrooms in mushroom houses.

It should be noted that the Agency has been informed by the producer (Cheminova) and IR4 that the following occupational use sites will not be supported for reregistration:

- All pet uses for all formulations;
- All livestock uses with all formulations;
- All indoor uses (except stored commodities and storage facilities);

- All greenhouse uses (except that mushroom use is presumed to be in mushroom houses for purposes of this assessment);
- All open-forest uses;
- All seed treatments with all formulations;
- All formulations for the following uses:
  - Almonds (including hulls and shells)
  - Cranberries
  - Filberts
  - Peanuts (including forage, hay, storage and storage facilities)
  - Peavines (including hay)
  - Safflower seed
  - Soybeans (including hay and forage)
  - Sugar beets
  - Sunflower seed
  - Treated raisin trays
- All pressurized can formulations.

Consequently, most of these use sites, while they may be included in the list of currently registered uses, have not been specifically included in the occupational exposure/risk assessment in this RED document.

**Non-occupational (Residential) Use Sites.** Potential residential and non-occupational use sites may include outdoor residential sites (e.g., use on ornamentals, lawns and vegetable gardens), professional uses at residential sites, and professional sites where non-occupational exposure may occur (exposure to treated ornamentals in parks, residential, and recreational areas, and exposure to treated trees in Christmas-tree plantations and pine forests). For ease and brevity, the non-occupational crops use sites in this RED have been grouped as follows:

- **Homeowner fruits and nuts,** including apples, cherries, grapes, peaches, plums, strawberries, oranges and tangerines.

- **Homeowner turf**.

- **Homeowner vegetables,** including beans, beets, broccoli, cabbage, collards, cucumbers, melons, tomatoes, peas and peppers.

- **Homeowner outdoor premise treatments**, including the perimeter of kennels and other residential structures.

- **Ornamentals at residences and within residential areas** (parks, recreation areas, etc.), including shade trees, evergreens, and roses.

### 1.5.5 Application rates

A policy decision was made to use the maximum application rates from residue field trials in support of food tolerances for the assessment of all agricultural uses. This decision was based on a statetment by the registrant of its intention to only support these agricultural use rates for the reregistration of malathion. The maximum label rates were used for all non-agricultural uses. Application rates used in the assessment are listed below:

- **Agricultural Crops:** The range of maximum application rates for agricultural crops is as follows: 6 lbs ai per acre for non-citrus, fruit-bearing trees and crops, such as pecans, apples, and pineapples (fruits and nuts); 2 lb ai per acre for ground crops including pumpkins, melons, and eggplants (ag pumpkin), and for citrus crops including apricots, cherries, peaches and nectarines (ag citrus fruit); and 0.5 lb ai per acre for various vegetables and field crops including beans, peas, rice, barley, and oats (ag veg).

- **ULV Agricultural Crops:** The maximum application rate for ultra low volume applications to agricultural crops such as alfalfa, barley, beans, cherries, and cotton is 1.2 lbs ai per acre.

- **Turf:** The maximum application rate for turf is 8.7 lbs ai per acre.

- **Ornamentals and Pine Trees:** The maximum application rate for ornamentals and trees is 2.6 lbs ai per acre.

- **Mosquitoes:** The maximum application rate for mosquitoes is 0.5 lbs ai per acre.

- **ULV Mosquitoes:** The maximum application rate for ultra low volume applications to mosquitoes is also 0.5 lbs ai per acre. (It should be noted that for the postapplication assessment, a ground fogger ULV application rate of 0.11 lb ai/A, and an aerial ULV application rate of 0.23 lb ai/A were used. These are maximum use rates from the major producers label (i.e., Cheminova's FYFANON® ULV) and better reflect the rates used in the studies upon which the post-application assessment is based.)

- **Grape Root Dip:** The maximum application rate for dipping grape roots is 1.9 lb ai per 100 gallons.

- **Storage Grain Facility:** The maximum application rate for stored grain such as corn, wheat, barley, oats and rye is 0.3 lbs ai per 1,000 square feet.

- **Berries:** The maximum application rate for berries is 4 lb ai per acre.

- **Agricultural Premises:** The maximum application rate for agricultural premises is 0.27 lb/gal.

- **Mushrooms:** The maximum application rate for mushrooms is 0.039 lb ai/1,000 square feet.

- **Homeowner Fruit Trees:** The maximum application rate for homeowner fruits is 0.034 lb ai/gallon.

- **Homeowner Ornamentals:** The maximum application rate for homeowner ornamentals is 0.034 lb ai/gallon.

- **Homeowner Turf:** The maximum application rate for homeowner turf is 0.18 lb ai/1000 sq. feet.

- **Homeowner Vegetable:** The maximum application rate for homeowner vegetables is 0.023 lb ai/gal.

- **Homeowner Mosquito and Other Household Pest Applications:** The maximum application rate for applying to mosquitoes and other household pests as a spray in a residential setting is 0.1547 lb ai/gal. The maximum application rate for applying to mosquitoes as a fogger in a residential setting is 0.012 lb ai/gal.

### 1.5.6 Methods and Types of Equipment Used for Mixing, Loading, and Application

- **Agricultural Crops:** Equipment for commercial use is groundboom sprayer, fixed-wing aircraft, chemigation equipment, helicopter, and airblast sprayer.
- **ULV Agricultural Crops:** Equipment for commercial use is fixed wing aircraft and helicopters.
- **Turf:** Equipment for commercial use is groundboom sprayer, fixed-wing aircraft, helicopter, low pressure handwand, backpack sprayer, hose end sprayer and turf handgun.
- **Ornamentals and Pine Trees:** Equipment for commercial use is groundboom equipment, chemigation equipment, fixed wing aircraft, airblast sprayer, helicopter, low pressure handwand, and backpack sprayer.
- **Mosquitoes:** Equipment for commercial use is fixed wing aircraft, helicopter, fogger, and paintbrush.
- **ULV Mosquitoes:** Equipment for commercial use is fixed wing aircraft, helicopter, and fogger.
- **Grape Root Dip:** Hand-dipped or semi-automated in racks.
- **Stored Grain Facility:** Equipment for commercial use includes a fixed sprayer and power duster for grain treatment and handheld sprayer for empty bin treatment.
- **Berries:** Equipment for commercial use includes groundboom sprayer, fixed wing aircraft, helicopter, and airblast sprayer.
- **Agricultural Premises:** Equipment for commercial use includes a low pressure handwand, and backpack sprayer.
- **Mushrooms:** Equipment for commercial use includes a hose end sprayer.
- **Homeowner Fruit Trees:** Equipment for residential use includes a low pressure handwand, hose end sprayer, and backpack sprayer.
- **Homeowner Ornamentals:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, and a shaker can.
- **Homeowner Turf:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer and a shaker can.
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- **Homeowner Vegetable:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, and a shaker can.

- **Homeowner Mosquito Applications:** Equipment for residential use includes a low pressure handwand, hose end sprayer, backpack sprayer, fogger, and a shaker can.

**1.5.7 Timing and Frequency of Applications -**

- **Agricultural Crops:** Repeat as necessary. Observe pre-harvest intervals, most of which are 1, 3, 7 or 14 days, depending upon the crop.

- **ULV Agricultural Crops:** Repeat as necessary. Observe pre-harvest intervals, most of which are 1, 3, 7 or 14 days, depending upon the crop.

- **Turf:** Repeat as necessary.

- **Ornamentals and Pine Trees:** Repeat as necessary.

- **Mosquitoes:** Repeat as necessary.

- **ULV Mosquitoes:** Repeat as necessary.

- **Grape Root Dip:** Assumed one treatment of nursery stock vines during winter season.

- **Stored Grain Facility:** For grain bin, after facility has been swept clean; as often as necessary. One treatment of grain (as it is going into storage); good for up to one year of storage.

- **Berries:** Begin applications when insects or their damage first appear, and repeat as necessary to maintain control.

- **Agricultural Premises:** As needed at approximately 2-week intervals.

- **Mushrooms:** Apply immediately after harvest and repeat twice per week as needed.

- **Homeowner Fruit Trees:** Typical applications are made when new spring growth for flowering begins. Repeat at 7-10 day intervals. A maximum number of applications or seasonal use rate has not been established.

- **Homeowner Ornamentals:** Apply when insects are present and repeat as necessary.

- **Homeowner Turf:** Repeat at 3 or 4 weeks, if necessary.

- **Homeowner Vegetable:** Apply one or more full coverage spray as needed.

- **Homeowner Mosquito Applications:** Apply as needed at 7-day intervals for residual adult mosquito control. Household insects: apply to lawns and a 10 foot wide stip along side of house at 7-day intervals, as needed. Fogging machines are recommended to be used at dusk, with repeat applications as necessary.

## 2.0 OCCUPATIONAL EXPOSURES AND RISKS

### 2.1 Handler Exposures and Risks

EPA has determined that there are potential exposures to mixers, loaders, applicators, and other handlers during usual use-patterns associated with malathion.

#### 2.1.1 Handler Exposure Scenarios

Based on the above listed use patterns which were developed from current labels, several major occupational exposure scenarios were identified for malathion:

(1a) mixing/loading liquids for groundboom application;
(1b) mixing/loading liquids for aerial and chemigation application;
(1c) mixing/loading liquids for airblast sprayer;
(1d) mixing/loading liquids for dipping;
(1e) mixing/loading liquids for a fogger;
(1f ) mixing/loading liquids for handgun;
(2) loading dusts for power duster or direct application;
(3a) mixing/loading wettable powders for groundboom application;
(3b) mixing/loading wettable powders for aerial application;
(3c) mixing/loading wettable powders for airblast sprayer;
(4) applying sprays with an airblast sprayer;
(5) applying sprays with a groundboom sprayer;
(6) applying sprays with a fixed-wing aircraft (also covers use of helicopter application);
(7) applying sprays with a fogger;
(8) applying dusts with a power duster;
(9) dipping plants;
(10) applying with a handgun (turf) sprayer;
(11) mixing/loading/applying liquid with a low pressure handwand;
(12) mixing/ loading/applying with a backpack sprayer;
(13) mixing/ loading/applying with a hose end sprayer;
(14) mixing/loading/applying with a paintbrush; and
(15) flagging for aerial spray application.

#### 2.1.2 Handler Exposure Scenarios -- Data and Assumptions

No chemical-specific handler exposure data were submitted in support of the reregistration of malathion. Therefore, an exposure assessment for each scenario was developed, where appropriate data are available, using the Pesticide Handlers Exposure Database (PHED) Version 1.1.[7] PHED was designed by a task force consisting of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide Regulation, and member companies of the American Crop Protection Association. PHED is a generic database containing measured exposure data for workers involved in the handling or application of pesticides in the field (i.e., currently contains data for over 2,000 monitored exposure events). The basic assumption underlying the system is that exposure to pesticide handlers can be calculated using the monitored data as exposure is primarily a function of the physical parameters of the handling and application process (e.g., packaging type, application method, and

clothing scenario). PHED also contains algorithms that allow the user to complete surrogate task-based exposure assessments beginning with one of the four main data files contained in the system (i.e., mixer/loader, applicator, flagger, and mixer/loader/applicator).

Users can select data from each major PHED file and construct exposure scenarios that are representative of the use of the chemical. However, to add consistency to the risk assessment process, the EPA in conjunction with the PHED task force has evaluated all data within the system and developed surrogate exposure tables that contain a series of standard unit exposure values for various exposure scenarios. These standard unit exposure values are based on the "best fit" values calculated by PHED. PHED calculates "best fit" exposure values by assessing the distributions of exposures for each body part included in datasets selected for the assessment (e.g., chest or forearm) and then calculating a composite exposure value representing the entire body. PHED categorizes distributions as normal, lognormal, or in any "other" category. Generally, most data contained in PHED are lognormally distributed or fall into the PHED "other" distribution category. If the distribution is lognormal, the geometric mean for the distribution is used in the "best fit" exposure value. If the data are an "other" distribution, the median value of the dataset is used in the calculation of the "best fit" exposure value. As a result, the surrogate unit exposure values that serve as the basis for this assessment generally range from the geometric mean to the median of the selected dataset.[7]

Table 3 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment. These caveats include the source of the data and an assessment of the overall quality of the data. The assessment of data quality is based on the number of observations and the available quality control data. The quality control data are based on a grading criteria established by the PHED task force.

The following assumptions and factors were used to complete this exposure assessment:

- Average body weight of an adult handler is 70 kg. This body weight is used in both the short- and intermediate-term assessment, since the endpoint of concern is not sex-specific (i.e., the cholinesterase inhibition could be assumed to occur in males or females).

- Average work day interval represents an 8 hour workday (e.g., the acres treated or volume of spray solution prepared in a typical day).

- Daily acres and volumes (as appropriate) to be treated in each scenario include:

  -- 350 acres for aerial and chemigation applications (including flaggers supporting aerial applications);
  -- 1,500 acres for mosquito aerial applications (non-ULV, e.g., EPA Reg. Nos. 10827-38 & 5905-196);
  -- 800 acres for ULV aerial applications to agricultural crops;
  -- 7,500 acres for ULV aerial applications to mosquitoes;
  -- 80 acres for groundboom applications to agricultural crops and berries;
  -- 10 acres for groundboom applications to ornamentals;
  -- 40 acres for airblast applications on agricultural crops, berries, and ornamentals;
  -- 160 gallons for fogger applications on mosquitoes using a thermal fogger;
  -- 16 gallons for ULV fogger applications on mosquitoes using a non-thermal fogger;
  -- 6,000 square feet for power duster to grain stored in storage silos;

-- 40 gallons for a low pressure handwand to treat stored grain facilities and agricultural premises;
-- 1000 square feet for low pressure handwand spot treatment of turf;
-- 5 acres for a low pressure handwand to ornamentals;
-- 5 acres for handgun turf;
-- 9,000 square feet for a hose end sprayer to mushroom houses;
-- 5 gallons for a paintbrush to windows screens and wineries for pest control.

- For fogging mosquitoes with a fogger, no PHED data were available; thus, as a surrogate, the PHED baseline unit exposure data for an airblast sprayer (0.36 mg/lb ai for dermal and 4.5 µg/lb for inhalation) were used to calculate dermal and inhalation exposure. In addition, the gallons handled were taken from information provided on the label (EPA Reg. 4787-8) which indicated that a thermal fogger sprays at a rate of 40 gal/hr and a non-thermal fogger sprays at a rate of 4 gal/hr. EPA assumed the fogger was used 4 hrs per day.

- For loading dusts for a power duster, no PHED data were available; thus, as a surrogate, the PHED baseline unit exposure data for wettable powders (3.7 mg/lb ai for dermal and 43 µg/lb for inhalation) were used to calculate dermal and inhalation exposure.

- Calculations are completed for a range of maximum application rates from residue field trials in support of food tolerance for agricultural uses based on the RED team memo.[1,3] For non-agricultural uses maximum application rates were identified for crop groupings, as listed on the available malathion labels and LUIS reports.[5,6] This results in an exposure/risk assessment that brackets risk levels associated with the various use patterns.

- When scenario-specific data are not available, HED calculates unit exposure values using generic protection factors that are applied to represent the use of personal protective equipment (PPE) and engineering controls.

### 2.1.3 Handler Exposure Risk Estimates

Handler exposure assessments are completed by EPA using a baseline exposure scenario and, if required, increasing levels of risk mitigation (PPE and engineering controls) to achieve a target margin of exposure. The baseline scenario generally represents a handler wearing long pants, a long-sleeved shirt, no respirator, and no chemical-resistant gloves. The calculation of baseline exposures are presented in Table 4. These daily exposures are used to complete the baseline dermal and inhalation risk assessment for the short and intermediate-term exposure scenarios (Table 5). Table 6 includes exposure/risk calculations for increasing levels of PPE. Table 7 includes exposure/risk calculations for engineering controls.

The calculations of daily dermal and inhalation exposure to malathion by handlers were used to calculate the daily dose, and hence the risks, to those handlers. Potential daily dermal exposure was calculated using the following formula:

$$Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{day}\right) = Unit\ Exposure\left(\frac{mg\ ai}{lb\ ai}\right) \times Use\ Rate\left(\frac{lb\ ai}{A}\right) \times Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A dermal absorption value was not needed for short- and intermediate-term dermal exposure because the dermal NOEL was based on a 21-day dermal study; however, for long-term (chronic) dermal exposure, a 2-year feeding study was used and a 10% dermal absorption correction factor was applied.

Potential daily inhalation exposure was calculated using the following formula:

$$Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) =$$
$$Unit\ Exposure\left(\frac{\mu g\ ai}{lb\ ai}\right)\ x\ Conversion\ Factor\left(\frac{1mg}{1{,}000\ \mu g}\right)\ x\ Use\ Rate\left(\frac{lb\ ai}{A}\right)\ x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A 100 percent inhalation absorption value was assumed.

The daily dermal and inhalation dose was calculated using a 70 kg body weight for both short-term and intermediate-term exposure as follows:

$$Daily\ Dermal\ Dose\left(\frac{mg\ ai}{Kg/Day}\right) = Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{Day}\right)\ x\left(\frac{1}{Body\ Weight\ (Kg)}\right)$$

$$Daily\ Inhalation\ Dose\left(\frac{mg\ ai}{kg/day}\right) = Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right)\ x\left(\frac{1}{Body\ Weight\ (kg)}\right)$$

The calculations of both the daily dermal dose and the daily inhalation dose of malathion received by handlers were used to calculate the short-term and intermediate-term dermal and inhalation MOEs. The dermal MOE was calculated using a NOEL of 50 mg/kg/day, and the inhalation MOE was calculated using a NOEL of 25.8 mg/kg/day. The following formula describes the calculation of a dermal MOE:

$$Dermal\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Dermal\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The following formula describes the calculation of an inhalation MOE:

$$Inhalation\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Inhalation\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The target dermal MOE, including short-, intermediate and long-term exposure periods, is 100. The target inhalation MOE, including short-, intermediate and long-term exposure periods, is 1000. Chronic

exposure is not expected for handlers, and therefore is not assessed. The short- and intermediate-term toxicity endpoint is the same (i.e., cholinesterase inhibition) for both dermal and inhalation exposure. Because the effect of concern is the same, the exposure contributed from both dermal and inhalation routes are added together. However, since the target MOEs are different for dermal (100) and inhalation (1000) exposure, the total risk is estimated by an Aggregate Risk Index (ARI). In order for the MOEs to be combined, there must be a common target MOE. If the MOE/Target MOE ratios for each route are treated as fractions, they can be adjusted to a common denominator of 1. This results in an ARI for dermal and an ARI for inhalation.

In order to calculate a Total ARI, the reciprocals of the dermal and inhalation ARIs are combined and divided into 1. The above operations are represented as follows:

$ARI_{dermal}$ = calculated dermal MOE ÷ target MOE (100)

$ARI_{inhalation}$ = calculated inhalation MOE ÷ target MOE (1000)

$$\text{Total ARI} = \frac{1}{\frac{1}{ARI_{dermal}} + \frac{1}{ARI_{inhalation}}}$$

A total ARI $\geq$ 1 in general, does not present a concern for handler exposure.

**Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion**

| Exposure Scenario (Number) | Data Source | Standard Assumptions[a] (8-hr work day) | Comments[b] |
|---|---|---|---|
| Mixer/Loader Descriptors | | | |
| Mixing/Loading Liquid Formulations (1a/1b/1c/1d/1e/1f) | PHED V1.1 (Revised Version 8/98) | 80 acres (ag) and 40 acres (golf course turf), 80 acres (sod farm) and 10 acres (ornamentals) for groundboom; 350 acres (ag, turf and pine trees), 1,500 acres (mosquitoes), 800 acres (ULV ag crops), 7,500 acre (ULV mosquitoes) for aerial and chemigation ; 40 acres (ag and ornamentals), for airblast sprayer, 100 gallons for grape root dip, 160 gallons for thermal fogger & 16 gallons for non-thermal fogger, and 5 acres for handgun (turf) | **Baseline:** Hands, dermal, and inhalation = AB grades. Hands = 53 replicates; Dermal = 72 to 122 replicates; and Inhalation = 85 replicates. High confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.:** The same dermal data are used as for baseline with gloves on hands. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing for all scenarios, except groundboom and fogger where a SINGLE layer of clothing only was needed. Hands = AB grades. Hands = 59 replicates. High confidence in hands data.<br><br>**Engineering Controls:** Hands, dermal, and inhalation = AB grades. Hands = 31 replicates; Dermal= 16 to 22; and Inhalation = 27 replicates. High confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value. |
| Mixing/Loading Dust Formulations (2) | PHED V1.1 (Revised Version 8/98) | 6,000 sq ft was assumed for grain (assumes maximum treatment of ten 60,000 bushel bins, each with a surface area of 600 sq ft) | **Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates; and Inhalation = 44 replicates. Low confidence in hands/ dermal, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.:** This assessment is not required.<br><br>**Engineering Controls:** This assessment is not required. |
| Mixing/Loading Wettable Powder Formulations (3a/3b/3c) | PHED V1.1 (Revised Version 8/98) | 80 acres for groundboom applications; 350 acres for aerial applications; and 40 acres for airblast applications | **Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates; and Inhalation = 44 replicates. Low confidence in hands/ dermal, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 24 replicates. Medium confidence in hands data.<br><br>**Engineering Controls**: Hands = AB grades; dermal and inhalation = all grade. Hands = 5 replicates; Dermal = 6 to 15 replicates; and Inhalation = 15 replicates. Low confidence in the hands, dermal and inhalation data. No protection factor was needed to define the unit exposure value. Engineering controls are based on water soluble packets. |

**Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)**

| Exposure Scenario (Number) | Data Source | Standard Assumptions[a] (8-hr work day) | Comments[b] |
|---|---|---|---|
| Applicator Descriptors | | | |
| Applying Sprays with an Airblast Sprayer (4) | PHED V1.1 (Revised Version 8/98) | 40 acres (ag, berries, and ornamentals) | **Baseline:** Hands, dermal , and inhalation = AB grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 18 replicates. High confidence in hands data.<br><br>**Engineering Controls:** Hands and dermal = AB grade, and inhalation = ABC grade. Back calculated from glove data assuming gloves provide 90% protection. Dermal = 27 to 30 replicates; and inhalation = 9 replicates. Low confidence in dermal data; and low confidence in inhalation data (based on low replicates). |
| Applying Sprays with a Groundboom Sprayer (5) | PHED V1.1 (Revised Version 8/98) | 80 acres (ag, sod farm and berries), 10 acres (ornamentals) and 40 acres for golf course turf | **Baseline**: Hands, dermal, and inhalation = AB grades. Hands =29 replicates, dermal = 23 to 42 replicates, and inhalation = 22 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.**: This assessment is not required.<br><br>**Engineering Controls**: This assessment is not required. |
| Applying Sprays with a Fixed-wing Aircraft (6)<br>[note: fixed-wing data are assumed to cover helicopter application, as well. Helicopter data in PHED are insufficient for a meaningful evaluation] | PHED V1.1 (Revised Version 8/98) | 350 acres (ag, ornamentals and turf), 1,500 acres (mosquitoes), 800 acres (ULV ag crops), and 7,500 acres (ULV mosquitoes) | **Engineering Controls:** Hands = AB grade, dermal and inhalation = ABC grade. Hands= 34 replicates, dermal = 24 to 48 replicates, and inhalation = 23 replicates. Medium confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. |

**Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)**

| Exposure Scenario (Number) | Data Source | Standard Assumptions[a] (8-hr work day) | Comments[b] |
|---|---|---|---|
| Applying Sprays with a Fogger (7) | PHED V1.1 (Revised Version 8/98) | 160 gallons thermal fogger (mosquitoes) and 16 gallons non-thermal fogger (mosquitoes) | **Baseline**: Hands, dermal , and inhalation = AB grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 18 replicates. High confidence in hands data.<br><br>**Engineering Controls**: Hands and dermal = AB grade, and inhalation = ABC grade. Back calculated from glove data assuming gloves provide 90% protection. Dermal = 27 to 30 replicates; and inhalation = 9 replicates. Low confidence in dermal data; and low confidence in inhalation data (based on low replicates). |
| Applying Dusts with a Power Duster (8) | No Data | 6,000 sq ft | No Data |
| Dipping Plants (9) | No Data | No Data | No Data |
| Applying with a Handgun (turf) Sprayer (10) | PHED V1.1 (Revised Version 8/98) | 5 acres | **Baseline:** Dermal = C grade (0 to 14 replicates). No Head and Neck data. Hands = C grade (14 replicates). Data for gloved hands only. Inhalation = B grade (14 replicates). Low confidence in dermal, hands and inhalation data.<br><br>**PPE:** The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data.<br><br>**Engineering Controls**: Not feasible. |
| Mixer/Loader/Applicator Descriptors | | | |
| Mixing/Loading/Applying with a Low Pressure Handwand (11) | PHED V1.1 (Revised Version 8/98) | 40 gal (grain and agricultural premises), 5 acres (ornamentals), 1acre for commercial and 1000 square feet for homeowner (spot treat turf) | **Baseline**: Dermal and inhalation = ABC grades; hands= all grades. Dermal = 9 to 80 replicates, inhalation = 80 replicates, and hands = 70 replicates. Low confidence in hands and dermal; and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.**: The same dermal data are used as for baseline. A 5-fold PF (e.g. 80% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 10 replicates. Low confidence in hands data.<br><br>**Engineering Controls**: Not feasible. |

**Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)**

| Exposure Scenario (Number) | Data Source | Standard Assumptions[a] (8-hr work day) | Comments[b] |
|---|---|---|---|
| Mixing/Loading/Applying with a Backpack Sprayer (12) | PHED V1.1 (Revised Version 8/98) | 40 gal (grain and agricultural premises) and 5 acres (ornamentals), 1acre for commercial and 1000 square feet for homeowner (spot treat turf) | **Baseline**: No data for dermal and hands. Inhalation= A grade. Inhalation= 11 replicates. Low confidence in inhalation data.<br><br>**PPE.**: Dermal= AB grade each, hands= C grade. Dermal= 9 to 11 replicates, and hands = 11 replicates. Low confidence in dermal and hands data. A 5-fold PF (e.g., 80% PF) was applied to the baseline inhalation data. A 50% PF was applied to dermal.<br><br>**Engineering Controls**: Not feasible. |
| Mixing/Loading/Applying with a Hose End Sprayer (13) | PHED V1.1 (Revised Version 8/98) | 9,000 sq ft (mushrooms) | **Baseline:** Hands = E grade, dermal = C grades, and inhalation = ABC grades. Hands = 8 replicates; Dermal = 8 replicates; and Inhalation = 8 replicates. Low confidence in hands/ dermal, and inhalation data. No protection factor was needed to define the unit exposure value.<br><br>**PPE.:** No Data<br><br>**Engineering Controls:** Not required for assessment. |
| Mixing/Loading/Applying with a Paintbrush (14) | PHEDV1.1 (Revised Version 8/98) | 5 gallons (mosquitoes) | **Baseline:** Dermal and inhalation = C grade; hands = AB grade. Dermal = 14 to 15 replicates, hands= 15 replicates and inhalation = 15 replicates. Low confidence in dermal, and hands data. Medium confidence in inhalation data.<br><br>**PPE.:** No Data<br><br>**Engineering Controls:** No Data |
| Flagger Descriptors | | | |
| Flagging Aerial Spray Applications (15) | PHED V1.1 (Revised Version 8/98) | 350 acres (ag, berries, ornamentals and turf), 1,500 acres (mosquitoes), 800 acres (ULV ag crops), and 7,500 acres (ULV mosquitoes). | **Baseline:** Hands, dermal, and inhalation = AB grades. Dermal = 18 to 28 replicates; Hands = 30 replicates; and Inhalation = 28 replicates. High confidence in dermal, hands, and inhalation data.<br><br>**PPE.**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = AB grades. Hands= 6 replicates. Low confidence in hands data.<br><br>**Engineering Controls**: Enclosed groundboom data are used as a surrogate for engineering controls for flaggers. Dermal and hands = ABC grades; Inhalation = AB grades. Dermal = 20 to 31 replicates; Hands = 16 replicates; and Inhalation = 16 replicates. Medium confidence in dermal and hands data. High confidence in inhalation data. |

**Table 3: Occupational Exposure Scenario Descriptions for the Use of Malathion (Continued)**

a Standard Assumptions based on an 8-hour work day as estimated by HED. BEAD data were not available.

b "Best Available" grades are defined by HED SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

**Table 4: Occupational Handler Short- and Intermediate-term Dermal and Inhalation Exposures to Malathion at Baseline**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Range of Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Mixer/Loader Exposure | | | | | | | |
| Mixing/Loading Liquids for Groundboom Application (1a) | 2.9 | 1.2 | 2 | ag (pumpkins)[2] | 80 acres | 460 | 0.19 |
| | | | 0.5 | ag (veg)[3] | | 120 | 0.048 |
| | | | 8.7 | golf course turf[4] | 40 acres | 1000 | 0.42 |
| | | | 8.7 | sod farms[4] | 80 acres | 2000 | 0.84 |
| | | | 2.6 | ornamentals[5] | 10 acres | 75 | 0.031 |
| Mixing/Loading Liquids for Aerial and Chemigation Application (1b) | 2.9 | 1.2 | 6 | ag (fruit & nut)[1] | 350 acres | 6,100 | 2.5 |
| | | | 2 | ag med[2] | | 2,000 | 0.84 |
| | | | 0.5 | ag low[3] | | 510 | 0.21 |
| | | | 8.7 | turf[4] | | 8,800 | 3.7 |
| | | | 2.6 | pine trees[5] | | 2,600 | 1.1 |
| | | | 0.5 | mosquitoes[6] | 1,500 acres | 2175 | 0.9 |
| | | | 1.2 | ULV ag crops[7] | 800 acres | 2784 | 1.2 |
| | | | 0.5 | ULV mosquitoes[8] | 7,500 acres | 10,875 | 4.5 |
| Mixing/Loading Liquids for Airblast Sprayer (1c) | 2.9 | 1.2 | 6 | ag (fruit & nut)[1] | 40 acres | 700 | 0.29 |
| | | | 2 | ag (citrus fruit)[2] | | 230 | 0.096 |
| | | | 2.6 | ornamentals[5] | | 300 | 0.12 |
| Mixing/Loading Liquids for Dipping (1d) | 2.9 | 1.2 | 1.9 lb ai/100 gal. | grape root dip[10] | 100 gal | 5.5 | 0.0023 |

**Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Range of Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Mixing/Loading Liquids for a Fogger (truck) (1e) | 2.9 | 1.2 | 0.51 lb ai/gal | thermal fogger[8] (mosquitoes) | 160 gal | 240 | 0.098 |
| | | | 9.9 lb ai/gal | non-thermal fogger[8] (mosquitoes) | 16 gal | 460 | 0.19 |
| Mixing/Loading Liquids for Handgun (1f) | 2.9 | 1.2 | 8.7 | turf[4] | 5 acres | 126 | 0.052 |
| Loading Dusts for Power Duster of Direct Application (2) | 3.7[h] | 43[h] | 0.3 lbs ai/1,000 sq. ft. | stored grain[11] | 6,000 sq. ft. | 6.7 | 0.077 |
| Mixing/Loading Wettable Powders for Groundboom Application (3a) | 3.7 | 43 | 4 | berries[9] | 80 acres | 1,200 | 14 |
| Mixing/Loading Wettable Powders for Aerial Application (3b) | 3.7 | 43 | 4 | berries[9] | 350 acres | 5,200 | 60 |
| Mixing/Loading Wettable Powders for Airblast Sprayer (3c) | 3.7 | 43 | 4 | berries[9] | 40 acres | 590 | 6.9 |
| Applicator Exposure | | | | | | | |
| Applying Sprays with an Airblast Sprayer (4) | 0.36 | 4.5 | 6 | ag (fruit & nut)[1] | 40 acres | 86 | 1.1 |
| | | | 4 | berries[9] | | 58 | 0.72 |
| | | | 2 | ag (citrus fruit)[2] | | 29 | 0.36 |
| | | | 2.6 | ornamentals[5] | | 37 | 0.50 |
| Applying Sprays with a Groundboom Sprayer (5) | 0.014 | 0.74 | 4 | berries[9] | 80 acres | 4.5 | 0.24 |
| | | | 2 | ag (pumpkins)[2] | | 2.2 | 0.12 |
| | | | 0.5 | ag (veg)[3] | | 0.56 | 0.030 |
| | | | 2.6 | ornamentals[5] | 10 acres | 0.36 | 0.019 |
| | | | 8.7 | golf course turf[4] | 40 acres | 4.9 | 0.26 |
| | | | 8.7 | sod farm[4] | 80 acres | 9.7 | 0.52 |

**Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Range of Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Applying Sprays with a Fixed-Wing Aircraft (6) | See Engineering Controls | See Engineering Controls | 6 | ag (fruit & nut)[2] | 350 acres | See Engineering Controls | See Engineering Controls |
| | | | 4 | berries[9] | | | |
| | | | 2 | ag (pumpkins)[2] | | | |
| | | | 0.5 | ag (veg)[3] | | | |
| | | | 2.6 | pine trees[5] | | | |
| | | | 8.7 | turf[4] | | | |
| | | | 0.5 | mosquitoes[6] | 1,500 acres | | |
| | | | 1.2 | ULV ag crops[7] | 800 acres | | |
| | | | 0.5 | ULV mosquitoes[8] | 7,500 acres | | |

**Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Range of Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Applying Sprays with a Fogger (7) | 0.36[i] | 4.5[i] | 0.51 lb ai/gal | thermal fogger[8] (mosquitoes) | 160 gal | 29 | 0.34 |
| | | | 9.9 lb ai/gal | non-thermal fogger[8] (mosquitoes) | 16 gal | 57 | 0.71 |
| Applying Dusts with a Power Duster (8) | No Data | No Data | 0.3 lb ai/1,000 sq. ft. | stored grains[11] | 6,000 sq. ft. | No Data | No Data |
| Dipping Plants (9) | No Data | No Data | 1.9 lb ai/100 gal | grape dip[11] | 100 gal | No Data | No Data |
| Applying with Handgun (turf) Sprayer (10) | 0.34[j] | 1.4 | 8.7 | turf[4] | 5 acres | 15 | 0.06 |
| Mixer/Loader/Applicator Exposure | | | | | | | |
| Mixing/Loading/Applying Liquid with a Low Pressure Handwand (11) | 100 | 30 | 5 lb ai/20 gallons | stored grain facility[11] | 40 gal | 1,000 | 0.3 |
| | | | 0.27 lb/gal | agricultural premises[12] | 40 gal | 1,100 | 0.32 |
| | | | 2.6 | ornamentals[5] | 5 acre | 1,300 | 0.39 |
| | | | 8.7 | turf[4] | 1 acre | 870 | 0.26 |
| Mixing/Loading/Applying liquids with a Backpack Sprayer (12) | See PPE. | See PPE. | 5 lb ai/20 gallons | stored grain facility[11] | 40 gal | See PPE. | See PPE. |
| | | | 0.27 lb ai/gal | agricultural premises[12] | 40 gal | | |
| | | | 2.6 | ornamentals[5] | 5 acres | | |
| | | | 8.7 | turf[4] | 1 acre | | |
| Mixing/Loading/Applying with a Hose End Sprayer (13) | 31 | 9.5 | 0.039 lb ai/1,000 sq. ft. | mushrooms[13] | 9,000 sq. ft. | 11 | 0.0033 |
| Mixing/Loading/Applying with a Paintbrush (14) | 180 | 280 | 0.1 lb ai/gal | mosquitoes[6] | 5 gal | 90 | 0.14 |

**Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Range of Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Flagger Exposure | | | | | | | |
| Flagging for Aerial Spray Applications (15) | 0.011 | 0.35 | 6 | ag (fruit & nut)[1] | 350 acres | 23 | 0.74 |
| | | | 4 | berries[9] | | 15 | 0.49 |
| | | | 2 | ag (pumpkins)[2] | | 7.7 | 0.25 |
| | | | 0.5 | ag (veg)[4] | | 1.9 | 0.061 |
| | | | 2.6 | pine trees[5] | | 10 | 0.32 |
| | | | 8.7 | turf[4] | | 33 | 1.1 |
| | | | 0.5 | mosquitoes[6] | 1,500 acres | 8.3 | 0.26 |
| | | | 1.2 | ULV ag crops[7] | 800 acres | 11 | 0.34 |
| | | | 0.5 | ULV mosquitoes[8] | 7,500 acres | 41 | 1.3 |

**Table 4: Occupational Handler Dermal and Inhalation Exposures to Malathion at Baseline (continued)**

**Footnotes:**

a Baseline dermal unit exposure represents long pants, long sleeved shirt, no gloves, and open mixing/loading. PHED Surrogate Exposure Guide - Draft. August 1998.
b Baseline inhalation unit exposure represents no respirator. PHED Surrogate Exposure Guide - Draft. August 1998.
c Application rates are based on maximum application rates from residue field trials in support of food tolerances.
d Crop types or targets are selected as follows:
- 1 Based on maximum application rates from residue field trials in support of food tolerances for pecans, apples, and pineapples.
- 2 Based on maximum application rates from residue field trials in support of food tolerances for pumpkins, melon, eggplant (groundboom & aerial) and cherries, citrus fruits, and peaches (airblast)
- 3 Based on maximum application rates from residue field trials in support of food tolerances for various vegetable crops.
- 4 Based on labeled maximum rates for turf, including golf course turf, sod farms and lawns of residences, businesses and parks. (EPA Reg. 655-777, 769-621 and 909-101)
- 5 Based on labeled maximum rates for ornamentals and pine trees (EPA Reg. 655-777 and 67760-1).
- 6 Based on labeled maximum rates for mosquitoes including standing water (based on residue field trials) and terrestrial uses (EPA Reg. 34704-108).
- 7 Based on labeled maximum rates for ULV-type agricultural crops (e.g., corn, wheat, and grain). (EPA Reg. 4787-8)
- 8 Based on labeled maximum rates for mosquitoes applications for ULV-type (EPA Reg. 4787-8).
- 9 Based on maximum application rates from residue field trials in support of food tolerances for berries.
- 10 Based on maximum application rates for grape root dip.
- 11 Based on maximum application rates for stored grain (surface treatments to corn, wheat, barley, oats, rye with dust formulations and treatment of grain storage facilities with EC formulations.
- 12 Based on maximum application rates for poultry premises and agricultural premises used as a bait spray.
- 13 Based on maximum application rates from residue field trials in support of food tolerances for mushrooms.

e Amount handled per day are from EPA estimates of acres treated, gallons applied, or square feet treated.
f Daily Dermal Exposure (mg/day) = Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).
g Daily Inhalation Exposure (mg/day) = Inhalation Unit Exposure ($\mu$g/lb ai) x (1 mg/1,000 $\mu$g) Conversion x Application rate (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.)
h Mixing/loading wettable powders is applied as a “surrogate” to mixing/loading dusts.
i Applying sprays with a fogger uses “surrogate” PHED data for applying sprays with an airblast sprayer.
j Because the dermal unit exposure in PHED includes protection from use of gloves, dermal risk is assessed in Table 6, and not under "Baseline" scenarios in Table 5.
NF Not Feasible.

**Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline.**

| Exposure Scenario (Scenario #) | Crop Type or Target | Baseline Dermal | | Baseline Inhalation | | Baseline Total |
|---|---|---|---|---|---|---|
| | | Daily Dose (mg/kg/day)[a] | MOE[b] (UF=100) | Daily Dose (mg/kg/day)[c] | MOE[d] (UF=1000) | Total Aggregate Risk index (ARI) [e] |
| Mixer/Loader Exposure | | | | | | |
| Mixing/Loading Liquids for Groundboom Application (1a) | ag (pumpkins) | 6.6 | 7.5 | 0.0027 | 9,400 | 0.08 |
| | ag (veg) | 1.7 | 30 | 0.00069 | 38,000 | 0.3 |
| | golf course turf | 14 | 3.5 | 0.0060 | 4,300 | 0.03 |
| | sod farm | 29 | 1.7 | 0.012 | 2,200 | 0.02 |
| | ornamentals | 1.1 | 46 | 0.00045 | 58,000 | 0.5 |
| Mixing/Loading Liquids for Aerial and Chemigation Application (1b) | ag (fruit & nut) | 87 | 0.6 | 0.036 | 720 | 0.01 |
| | ag (pumpkin) | 29 | 1.7 | 0.012 | 2,200 | 0.02 |
| | ag (veg) | 7.3 | 6.9 | 0.0030 | 8,600 | 0.07 |
| | turf | 130 | 0.4 | 0.052 | 490 | 0.004 |
| | pine trees | 38 | 1.3 | 0.016 | 1,700 | 0.01 |
| | mosquitoes | 31 | 1.6 | 0.013 | 2,000 | 0.02 |
| | ULV ag crops | 40 | 1.3 | 0.017 | 1,500 | 0.01 |
| | ULV mosquitoes | 155 | 0.32 | 0.064 | 400 | 0.003 |
| Mixing/Loading Liquids for Airblast Sprayer (1c) | ag (fruit & nut) | 9.9 | 5.0 | 0.0041 | 6,300 | 0.04 |
| | ag (citrus fruit) | 3.3 | 15 | 0.0014 | 19,000 | 0.15 |
| | ornamentals | 4.3 | 12 | 0.0018 | 14,000 | 0.12 |
| Mixing/Loading Liquids for Dipping (1d) | grape root dip | 0.079 | 640 | 0.000033 | 790,000 | 6.3 |

**Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Baseline Dermal | | Baseline Inhalation | | Baseline Total |
|---|---|---|---|---|---|---|
| | | Daily Dose (mg/kg/day)[a] | MOE[b] (UF=100) | Daily Dose (mg/kg/day)[c] | MOE[d] (UF=1000) | Total Aggregate Risk index (ARI) [e] |
| Mixing/Loading Liquids for a Fogger (1e) | thermal fogger (mosquitoes) | 3.4 | 15 | 0.0014 | 18,000 | 0.15 |
| | non-thermal fogger (mosquitoes) | 6.6 | 7.6 | 0.0027 | 9,500 | 0.08 |
| Mixing/Loading Liquids for Handgun (1f) | turf | 1.8 | 28 | 0.00075 | 35,000 | 0.28 |
| Mixing/Loading Dusts for Power Duster or Direct Application (2) | stored grain facility | 0.095 | 530 | 0.0011 | 23,000 | 4.4 |
| Mixing/Loading Wettable Powders for Groundboom Application (3a) | berries | 17 | 3 | 0.20 | 130 | 0.02 |
| Mixing/Loading Wettable Powders for Aerial Application (3b) | berries | 74 | 0.68 | 0.86 | 30 | 0.01 |
| Mixing/Loading Wettable Powders for Airblast Sprayer (3c) | berries | 8.5 | 5.9 | 0.098 | 260 | 0.21 |
| Applicator Exposure | | | | | | |
| Applying Sprays with an Airblast Sprayer (4) | ag (fruit & nut) | 1.2 | 41 | 0.015 | 1,700 | 0.33 |
| | berries | 0.82 | 61 | 0.010 | 2,500 | 0.5 |
| | ag (citrus fruit) | 0.41 | 120 | 0.0051 | 5,000 | 1.0 |
| | ornamentals | 0.53 | 93 | 0.0067 | 3,900 | 0.84 |
| Applying Sprays with a Groundboom Sprayer (5) | berries | 0.064 | 780 | 0.0034 | 7,600 | 4.0 |
| | ag (pumpkins) | 0.032 | 1,600 | 0.0017 | 15,000 | 7.7 |
| | ag (veg) | 0.008 | 6,300 | 0.00042 | 61,000 | 31 |
| | ornamentals | 0.005 | 9,600 | 0.00027 | 94,000 | 48 |
| | golf course turf | 0.07 | 720 | 0.0037 | 7,000 | 3.6 |
| | sod farm | 0.14 | 360 | 0.0074 | 3,500 | 1.8 |

**Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Baseline Dermal | | Baseline Inhalation | | Baseline Total |
|---|---|---|---|---|---|---|
| | | Daily Dose (mg/kg/day)[a] | MOE[b] (UF=100) | Daily Dose (mg/kg/day)[c] | MOE[d] (UF=1000) | Total Aggregate Risk index (ARI) [e] |
| Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6) | ag (fruit& nut), berries, ag (pumpkins), ag (veg), pine trees, turf, mosquitoes, ULV ag crops, ULV mosquitoes | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls |
| Applying Sprays with a Fogger (7) | thermal fogger (mosquitoes) | 0.42 | 120 | 0.0052 | 4,900 | 1.0 |
| | non-thermal fogger (mosquitoes) | 0.81 | 61 | 0.010 | 2,500 | 0.5 |
| Applying Dusts with a Power Duster (8) | stored grain facility | No Data | No Data | No Data | No Data | No Data |
| Dipping Plants (9) | grape root dip | No Data | No Data | No Data | No Data | No Data |
| Applying with a Handgun (turf) Sprayer (10) | turf | see PPE. | see PPE | see PPE | see PPE | see PPE |
| Mixer/Loader Applicator Exposure | | | | | | |
| Mixing/Loading/Applying with a Low Pressure Handwand (11) | stored grain facility | 14 | 3.5 | 0.0043 | 6,000 | 0.03 |
| | agricultural premises | 15 | 3.2 | 0.0046 | 5,600 | 0.03 |
| | ornamentals | 19 | 2.7 | 0.0056 | 4,600 | 0.03 |
| | turf | 12 | 4.2 | 0.0037 | 7,000 | 0.04 |
| Mixing/Loading/Applying with a Backpack Sprayer (12) | grain | See PPE. | See PPE. | See PPE. | See PPE. | See PPE. |
| | agricultural premises | | | | | |
| | ornamentals | | | | | |
| | turf | | | | | |
| Mixing/Loading/Applying with a Hose End Sprayer (13) | mushrooms | 0.16 | 320 | 4.8E-05 | 5.4E+05 | 3.2 |

**Table 5: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Baseline Dermal | | Baseline Inhalation | | Baseline Total |
|---|---|---|---|---|---|---|
| | | Daily Dose (mg/kg/day)[a] | MOE[b] (UF=100) | Daily Dose (mg/kg/day)[c] | MOE[d] (UF=1000) | Total Aggregate Risk index (ARI) [e] |
| Mixing/Loading/Applying with a Paintbrush(14) | mosquitoes | 1.3 | 39 | 0.002 | 13,000 | 0.37 |
| Flagger Exposure | | | | | | |
| Flagging for Aerial Spray Applications (15) | ag (fruit & nut) | 0.33 | 150 | 0.011 | 2,500 | 0.94 |
| | berries | 0.22 | 230 | 0.0070 | 3,700 | 1.4 |
| | ag (pumpkin) | 0.11 | 450 | 0.0035 | 7,400 | 2.8 |
| | ag (veg) | 0.028 | 1,800 | 0.00088 | 29,000 | 13 |
| | pine trees | 0.14 | 350 | 0.0046 | 5,700 | 2.2 |
| | turf | 0.48 | 100 | 0.015 | 1,700 | 0.63 |
| | mosquitoes | 0.12 | 420 | 0.0038 | 6,900 | 2.6 |
| | ULV ag crops | 0.15 | 330 | 0.0048 | 5,400 | 2.0 |
| | ULV mosquitoes | 0.59 | 85 | 0.019 | 1,400 | 0.5 |

[a] Daily Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day)/ Body weight (70 kg).
[b] Dermal MOE (short- and intermediate-term) = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).
[c] Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day)/ Body weight (70 kg).
[d] Inhalation MOE (short- and intermediate-term) = NOEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).
[e] Total ARI (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE/Target Dermal MOE (100)) + (1 /Calculated Inhalation MOE/Target Inhalation MOE (1000))).
NF Not Feasible.

**Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE.**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Additional PPE. | | | Inhalation - Additional PPE. | | | Total - Additional PPE. |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] (UF=100) | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] (UF=1000) | Total Aggregate Risk Index (ARI)[f] |
| Mixer/Loader Exposure | | | | | | | | |
| Mixing/Loading Liquids for Groundboom Application (1a) | ag (pumpkins) | 0.023 (Gloves only) | 0.053 | 950 | 1.2 (No respirator) | 0.0027 | 9,400 | 4.7 |
| | ag(veg) | | 0.013 | 3,800 | | 0.00069 | 38,000 | 19 |
| | golf course turf | | 0.11 | 440 | | 0.006 | 4,300 | 2.2 |
| | sod farms | | 0.23 | 220 | | 0.012 | 2,200 | 1.1 |
| | ornamentals | | 0.0085 | 5,900 | | 0.00045 | 58,000 | 29 |
| Mixing/Loading Liquids for Aerial and Chemigation Application (1b) | ag (fruit & nut) | 0.017 | 0.51 | 98 | 0.24 | 0.0072 | 3,600 | 0.8 |
| | ag (pumpkins) | | 0.17 | 290 | 1.2 (No respirator) | 0.012 | 2,200 | 1.2 |
| | ag (veg) | | 0.043 | 1,200 | | 0.003 | 8,600 | 5 |
| | turf | | 0.74 | 68 | 0.24 | 0.010 | 2,500 | 0.5 |
| | pine trees | | 0.22 | 230 | | 0.0031 | 8,300 | 1.8 |
| | mosquitoes | | 0.18 | 280 | 1.2 (No respirator) | 0.013 | 2,000 | 1.2 |
| | ULV ag crops | | 0.23 | 220 | 0.24 | 0.0033 | 7,800 | 1.7 |
| | ULV mosquitoes | | 0.91 | 55 | | 0.013 | 2,000 | 0.4 |
| Mixing/Loading Liquids for Airblast Sprayer (1c) | ag (fruit & nut) | 0.017 | 0.058 | 860 | 1.2 (No respirator) | 0.0041 | 6,300 | 3.7 |
| | ag (citrus fruit) | 0.023 (Gloves only) | 0.026 | 1900 | | 0.0014 | 19,000 | 9.5 |
| | ornamentals | | 0.034 | 1500 | | 0.0018 | 14,000 | 7.6 |
| Mixing/Loading Liquids for Dipping (1d) | grape root dip | NA | NA | NA | NA | NA | NA | NA |

**Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Additional PPE. | | | Inhalation - Additional PPE. | | | Total - Additional PPE. |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] (UF=100) | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] (UF=1000) | Total Aggregate Risk Index (ARI)[f] |
| Mixing/Loading Liquids for a Fogger (1e) | thermal fogger (mosquitoes) | 0.023 (Gloves only) | 0.027 | 1,900 | 1.2 (No respirator) | 0.0014 | 18,000 | 10 |
| | non-thermal fogger (mosquitoes) | | 0.052 | 960 | | 0.0027 | 9,500 | 5 |
| Mixing/Loading Liquids for Handgun (1f) | turf | 0.023 (Gloves only) | 0.014 | 3,500 | 1.2 (No respirator) | 0.00075 | 35,000 | 17 |
| Loading Dusts for Power Duster or Direct Application (2) | stored grain facility | NA | NA | NA | NA | NA | NA | NA |
| Mixing/Loading Wettable Powders for Groundboom Application (3a) | berries | 0.13 | 0.59 | 85 | 8.6 | 0.039 | 660 | 0.4 |
| Mixing/Loading Wettable Powders for Aerial Application (3b) | berries | | 2.6 | 19 | | 0.17 | 150 | 0.08 |
| Mixing/Loading Wettable Powders for Airblast Sprayer (3c) | berries | | 0.30 | 170 | | 0.020 | 1,300 | 0.7 |
| Applicator Exposure | | | | | | | | |
| Applying Sprays with an Airblast Sprayer (4) | ag (fruit & nut) | 0.22 | 0.75 | 67 | 0.9 | 0.003 | 8,400 | 0.6 |
| | berries | | 0.50 | 100 | | 0.002 | 13,000 | 0.93 |
| | ag (citrus fruit) | | NA | NA | | NA | NA | NA |
| | ornamentals | | 0.33 | 150 | | 0.001 | 19,000 | 1.4 |
| Applying Sprays with a Groundboom Sprayer (5) | ag (pumpkin), berries, ag (veg), ornamentals and turf | NA | NA | NA | NA | NA | NA | NA |
| Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6) | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls | See Eng. Controls |

**Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Additional PPE. | | | Inhalation - Additional PPE. | | | Total - Additional PPE. |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] (UF=100) | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] (UF=1000) | Total Aggregate Risk Index (ARI)[f] |
| Applying Sprays with a Fogger (7) | thermal fogger (mosquitoes) | 0.22 | NA | NA | 0.9 | NA | NA | NA |
| | non-termal fogger (mosquitoes) | | 0.50 | 100 | | 0.0021 | 13,000 | 0.93 |
| Applying Dusts with a Power Duster (8) | stored grain facility | No Data | No Data | No Data | No Data | No Data | No Data | No Data |
| Dipping Plants (9) | grape root dip | No Data | No Data | No Data | No Data | No Data | No Data | No Data |
| Applying with Handgun (turf) Sprayer (10) | turf | 0.34 (Gloves only) | 0.21 | 230 | 1.4 (No respirator) | 0.00086 | 3.0E +04 | 2 |
| Mixer/Loader/Applicator Exposure | | | | | | | | |
| Mixing/Loading/Applying with a Low Pressure Handwand (11) | stored grain facility | 0.43 (Gloves only) | 0.06 | 810 | 30 (No respirator) | 0.0043 | 6000 | 3.4 |
| | agricultural premises | | 0.07 | 750 | | 0.0046 | 5600 | 3.3 |
| | ornamentals | | 0.08 | 630 | | 0.0056 | 4600 | 2.5 |
| | turf | | 0.05 | 1000 | | 0.0037 | 7000 | 4.2 |
| Mixing/Loading/Applying with a Backpack Sprayer (12) | stored grain facility | 2.5 (Gloves only) | 0.36 | 140 | 30 (No respirator) | 0.0043 | 6000 | 1.1 |
| | agricultural premises | | 0.39 | 130 | | 0.0046 | 5600 | 1.0 |
| | ornamentals | 1.6 | 0.30 | 170 | | 0.0056 | 4600 | 1.2 |
| | turf | 2.5 (Gloves only) | 0.31 | 1600 | | 0.0037 | 7000 | 1.3 |
| Mixing/Loading/Applying with a Hose End Sprayer (13) | mushrooms | NA | NA | NA | NA | NA | NA | NA |
| Mixing/Loading/Applying with a Paintbrush (14) | mosquitoes | No Data | No Data | No Data | No Data | No Data | No Data | No Data |

**Table 6: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Additional PPE. (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Additional PPE. | | | Inhalation - Additional PPE. | | | Total - Additional PPE. |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] (UF=100) | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] (UF=1000) | Total Aggregate Risk Index (ARI)[f] |
| Flagger Exposure | | | | | | | | |
| Flagging for Aerial Spray Applications (15) | ag (fruit & nut), berries, ag (pumpkins) ag (veg), ornamentals, mosquitoes, & ULV ag crops | NA | NA | NA | NA | NA | NA | NA |
| | turf | 0.010 | 0.48 | 100 | 0.07 | 0.0030 | 8,500 | 0.89 |
| | ULV mosquitoes | | 0.59 | 85 | | 0.0038 | 6,900 | 0.80 |

[a] Except where indicated in the Table, additional PPE. for all scenarios includes DOUBLE layer of clothing), chemical resistant gloves, and dust/mist respirator (5-fold PF).
[b] Daily Dermal Dose (mg/kg/day) is calculated using PPE. unit exposure and exposure algorithms presented in Table 1.
[c] Dermal MOE = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).
[d] Daily Inhalation Dose (mg/kg/day) is calculated using PPE. unit exposure and exposure algorithms presented in Table 1.
[e] Inhalation MOE = NOEL (25.8 mg/kg/day) / (Daily Inhalation Dose (mg/kg/day).
[f] Total ARI (short- and Intermediate-term) = 1 / ((1/Dermal MOE/100) + (1 /Inhalation MOE/1000)).
NF Not Feasible
NA Not Applicable - Because previous level of mitigation resulted in total ARI >1.

**Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Engineering Controls | | | Inhalation - Engineering Controls | | | Total - Eng. Controls |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] | Total Aggregate Risk Index (ARI)[f] |
| Mixer/Loader Exposure | | | | | | | | |
| Mixing/Loading Liquids for Groundboom Application (1a) | ag (pumpkins), ag (veg), golf course turf, sod farms & ornamentals | NA | NA | NA | NA | NA | NA | NA |
| Mixing/Loading Liquids for Aerial and Chemigation Application (1b) | ag (fruit & nut) | 0.0086 | 0.26 | 190 | 0.083 | 0.0025 | 10,000 | 1.6 |
| | ag (pumpkins), ag (veg), mosquitoes, pine trees & ULV ag crops | | NA | NA | | NA | NA | NA |
| | turf | | 0.37 | 135 | | 0.0036 | 7,200 | 1.1 |
| | ULV mosquitoes | | 0.46 | 110 | | 0.0044 | 5,800 | 0.93 |
| Mixing/Loading Liquids for Airblast Sprayer (1c) | ag (fruit & nut) | NA | NA | NA | NA | NA | NA | NA |
| | ag (citrus fruit), & ornamentals | | | | | | | |
| Mixing/Loading Liquids for Dipping (1d) | grape root dip | NA | NA | NA | NA | NA | NA | NA |
| Mixing/Loading Liquids for a Fogger (truck) (1e) | thermal fogger (mosquitoes) | NA | NA | NA | NA | NA | NA | NA |
| | non-thermal fogger (mosquitoes) | | | | | | | |
| Mixing/Loading Liquids for a Handgun (1f) | turf | NA | NA | NA | NA | NA | NA | NA |
| Loading Dusts for Power Duster or Direct Application (2) | stored grain facility | NA | NA | NA | NA | NA | NA | NA |
| Mixing/Loading Wettable Powders for Groundboom Application (3a) | berries | 0.0098 | 0.045 | 1,100 | 0.24 | 0.0011 | 24,000 | 8 |
| Mixing/Loading Wettable Powders for Aerial Application (3b) | berries | | 0.20 | 260 | | 0.0048 | 5,400 | 1.7 |
| Mixing/Loading Wettable Powders for Airblast Sprayer (3c) | berries | | 0.02 | 2500 | | 0.0005 | 52,000 | 4 |
| Applicator Exposure | | | | | | | | |
| Applying Sprays with an Airblast Sprayer (4) | ag (fruit & nut) | 0.14 | 0.48 | 100 | 0.45 | 0.0015 | 17,000 | 0.94 |
| | berries | | 0.32 | 160 | | 0.0010 | 26,000 | 1.5 |

**Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Engineering Controls | | | Inhalation - Engineering Controls | | | Total - Eng. Controls |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] | Total Aggregate Risk Index (ARI)[f] |
| | ag (citrus fruit), ornamentals | | NA | NA | | NA | NA | NA |
| Applying Sprays with a Groundboom Sprayer (5) | ag (pumpkin), berries, ag (veg), ornamentals & turf | NA | NA | NA | NA | NA | NA | NA |
| Applying Sprays with a Fixed-Wing Aircraft (liquid formulations) (6) | ag (fruit & nut) | 0.0050 | 0.15 | 330 | 0.068 | 0.0020 | 13,000 | 3 |
| | berries | | 0.10 | 500 | | 0.0014 | 18,000 | 4 |
| | ag (pumpkins) | | 0.05 | 1,000 | | 0.00068 | 38,000 | 8 |
| | ag (veg) | | 0.013 | 4,000 | | 0.00017 | 150,000 | 25 |
| | pine trees | | 0.065 | 770 | | 0.00088 | 29,000 | 6 |
| | turf | | 0.22 | 230 | | 0.0030 | 8,600 | 1.8 |
| | mosquitoes | | 0.054 | 930 | | 0.00073 | 35,000 | 7 |
| | ULV ag crops | | 0.069 | 730 | | 0.00093 | 28,000 | 6 |
| | ULV mosquitoes | | 0.27 | 190 | | 0.0036 | 7,200 | 1.5 |
| Applying Sprays with a Fogger (7) | thermal fogger (mosquitoes) | 0.14 | NA | NA | 0.45 | NA | NA | NA |
| | non-thermal fogger (mosquitoes) | | 0.32 | 160 | | 0.0010 | 26,000 | 1.5 |
| Applying Dusts with a Power Duster (8) | stored grain facility | No Data | No Data | No Data | No Data | No Data | No Data | No Data |
| Dipping Plants (9) | grape root dip | No Data | No Data | No Data | No Data | No Data | No Data | No Data |
| Applying with Handgun (turf) Sprayer (10) | turf | NA | NA | NA | NA | NA | NA | NA |
| Mixer/Loader/Applicator Exposure | | | | | | | | |
| Mixing/Loading/Applying with a Low Pressure Handwand (11) | stored grain facility, agricultural premises, ornamentals and turf | None | NF | NF | None | NF | NF | NF |

**Table 7: Occupational Handler Short-term and Intermediate-term Risks from Malathion with Engineering Controls (continued)**

| Exposure Scenario (Scenario #) | Crop Type or Target | Dermal - Engineering Controls | | | Inhalation - Engineering Controls | | | Total - Eng. Controls |
|---|---|---|---|---|---|---|---|---|
| | | Unit Exposure (mg/lb ai)[a] | Daily Dose (mg/kg/day)[b] | MOE[c] | Unit Exposure (µg/lb ai)[a] | Daily Dose (mg/kg/day)[d] | MOE[e] | Total Aggregate Risk Index (ARI)[f] |
| Mixing/Loading/Applying with a Backpack Sprayer (12) | stored grain facility, agricultural premises, ornamentals and turf | None | NF | NF | None | NF | NF | NF |
| Mixing/Loading/Applying with a Hose End Sprayer (13) | mushrooms | None | NF | NF | None | NF | NF | NF |
| Mixing/Loading/Applying with a Paintbrush (14) | mosquitoes | None | NF | NF | None | NF | NF | NF |
| Flagger Exposure | | | | | | | | |
| Flagging for Aerial Spray Applications (15) | ag (fruit & nut), berries, ag (pine trees), ag (veg), pine trees, mosquitoes, & ULV ag crops | NA | NA | NA | NA | NA | NA | NA |
| | turf | 0.005 | 0.22 | 230 | 0.007 | 0.0003 | 86,000 | 2.2 |
| | ULV mosquitoes | | 0.12 | 420 | | 0.00017 | 152,000 | 4.1 |

**Footnotes:**

[a] Engineering Controls:
1b/1c/1d/1e: Closed mixing/loading, single layer clothing, chemical resistant gloves.
3: Water soluble packets
4: Enclosed cab, single layer clothing, no gloves.
6: Enclosed cockpit, single layer clothing, no gloves.
7: Enclosed cockpit, single layer clothing, no gloves.
8: Enclosed cab, single layer clothing, no gloves.
15: Enclosed cab, single layer clothing, no gloves.

[b] Daily Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day)/ Body weight (70 kg).

[c] Dermal MOE = NOEL (50 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).

[d] Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day)/ Body weight (70 kg).

[e] Inhalation MOE = NOEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

[f] Total ARI (short- and Intermediate-term) = 1 / ((1/Dermal MOE/100) + (1 /Inhalation MOE/1000)).

NF Not Feasible

NA Not Applicable - Because previous level of mitigation resulted in total ARI >1.

### 2.1.4 Handler Exposure and Risk Estimates for Cancer

In accordance with the EPA *Proposed Guidelines for Carcinogen Risk Assessment* (July 1999), the Cancer Assessment Review Committee at the 12-April-2000 meeting, classified malathion as **"suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential"** by all routes of exposure. **Quantitative risk assessment for carcinogenicity is NOT required** since the Committee classified malathion as having suggestive evidence for cancer. A cancer dose-response assessment, e.g., a low dose linear extrapolation model, is not indicated for pesticides in the "suggestive"category.

### 2.1.5 Summary of Occupational Handler Risk Concerns, Data Gaps, and Confidence in Exposure and Risk Estimates

**Summary of Short- and Intermediate-Term Risks**

The toxicological endpoints for short-term and intermediate-term exposures were the same; therefore, these exposure scenarios were developed in one table. A chronic risk assessment was not completed for the handlers because the use patterns do not indicate any chronic exposure patterns.

**Handler Scenarios with Risk Outcomes.** The calculations indicate that the total ARIs (which include both short- and intermediate-term exposures) are greater than, or equal to 1 at **baseline** for the following scenarios:

- (1d) mixing/loading liquids for dipping
- (2) mixing/loading dusts for power duster or direct application (grain)
- (4) applying sprays with an airblast sprayer (ag citrus fruit)
- (5) applying sprays with a groundboom sprayer (all crops).
- (7) applying outdoor sprays with a thermal fogger (mosquitoes).
- (13) mixing/loading/applying with a hose end sprayer (mushrooms) .
- (15) flagging aerial spray applications berries, ag (pumpkins), ag (veg), pine trees, mosquitoes, and ULV ag crops).

The calculations indicate that the total ARIs (which include both short- and intermediate-term exposures) are greater than, or equal to 1 with additional **PPE *** for the following scenarios:

- (1a) mixing/loading liquids for groundboom application (all crops - *gloves only*, *no respirator*).
- (1b) mixing/loading liquids for aerial and chemigation application (ag pumpkins - *no respirator*, ag veg - *no respirator*, pine trees, mosquitoes - *no respirator*, and ULV ag crops).
- (1c) mixing/loading liquids for airblast sprayer (ag fruit & nut - *no respirator*, ag citrus fruit - *gloves only, no respirator*, and ornamentals - *gloves only, no respirator*).
- (1e) mixing/loading liquids for a thermal or non-thermal fogger (mosquitoes - *gloves only, no respirator*).
- (4) applying sprays with an airblast sprayer (ornamentals).
- (10) applying handgun sprayer (turf - gloves only, no respirator).
- (11) mixing/loading/applying with a low pressure handwand (all crops - *gloves only, no respirator*).
- (12) mixing/loading/applying with a backpack sprayer (stored grain facility - *gloves only, no respirator*, agricultural premises - *gloves only, no respirator*, ornamentals - *no respirator*, and turf - *gloves only, no respirator*).

* Except where indicated in italics, additional PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator.

The calculations indicate that the total ARIs (which include both short- and intermediate-term exposures) are greater than, or equal to 1 with additional **engineering controls** for the following scenarios:

- (1b) mixing/loading liquids for aerial and chemigation application (ag fruit & nut, and turf).
- (3a) mixing/loading wettable powders for groundboom application (berries).
- (3b) mixing/loading wettable powders for aerial application (berries).
- (3c) mixing/loading wettable powders for airblast sprayer (berries).
- (4) applying sprays with an airblast sprayer (berries).
- (6) applying sprays with a fixed-wing aircraft (all crops).
- (7) applying sprays with a fogger (non-thermal fogger for mosquitoes).
- (15) flagging aerial spray applications (turf and ULV mosquitoes).

The calculations indicate that the total ARIs (which include both short- and intermediate-term exposures) are not greater than, or equal to 1 despite the maximum mitigation measures for the following scenarios:

- (1b) mixing/loading liquids for aerial and chemigation application (ULV mosquitoes)
- (4) applying sprays with an airblast sprayer (ag fruit & nut)

**Data Gaps.** Data gaps exist for the following scenarios:

- (8) applying dusts with a power duster; no PHED data exist.
- (9) dipping plants; no PHED data exist.
- (12) mixing/loading/applying with a backpack sprayer; no PHED data exist for baseline.

**Data Quality and Confidence in Assessment**. Several issues must be considered when interpreting the occupational exposure risk assessment. These include:

- Several handler assessments were completed using “low quality” PHED data. The resulting uncertainty means that the actual risks could be greater, or less than the risks estimated with these data.

- Several generic protection factors were used to calculate handler exposures. The protection factors used in this assessment are generally accepted by HED, but have not been externally peer reviewed. Specific mitigation measures may yield greater or less protection than is assumed. The ones used are considered to be reasonable high-end estimates.

- Factors used to calculate daily exposures to handlers (e.g., acres treated per day, square feet applied, and gallons of liquid applied) are based on the best professional judgement of HED staff, but have not been externally peer reviewed.

- PHED mixer/loader data for wettable powder are used as a surrogate for dusts.

- PHED applicator data for airblast are used as a surrogate for fogger.

## 2.2 Occupational Post-Application Exposures and Risks

### 2.2.1 Postapplication Exposure Scenarios

EPA has determined that there are potential intermediate-term occupational postapplication exposures to individuals entering treated fields and potential long-term occupational postapplication exposures to individuals harvesting mushrooms; specific postapplication activities are listed below and further defined in the subsequent section:

- Harvesting crops that have a high potential for dermal contact and all reentry activities associated with tree crops;
- Non-harvesting reentry activities with crops that have potential for a high degree of dermal contact;
- Harvesting and non-harvesting reentry activities with crops that have potential for a medium degree of dermal contact;
- Harvesting activities with crops that have potential for a low degree of dermal contact;
- Non-harvesting activities with crops that have potential for a low degree of dermal contact;
- Transplanting and pruning ornamental shrubs and trees.
- Harvesting, hand girdling, caning, tying, pruning, thinning, and tipping grapes.
- Mowing and maintaining turfgrass.
- Cutting, rolling and harvesting sodgrass.
- Harvesting mushrooms (acute/intermediate and chronic exposure).

### 2.2.2 Basis and Approach for Assessment of Postapplication Scenarios

A transferable residue study on turf (MRID 441133-01) was conducted with malathion formulated as the end use product Malathion 57EC. This study examined the residue levels of malathion that could be transferred from treated turf. Four geographic sites were included in this study to represent the different use areas in the United States. These sites represented cool season grass in the Northeast/mid Atlantic, cool season grass in the Midwest, warm season grass in the South Atlantic/Gulf region, and warm season grass in the Pacific Coastal region.

At each site, one application of the 57EC, with a target rate of 5 lb ai per acre (4 quarts of formulated product in 100 gallons of water), was performed with hand-gun spray equipment. These conditions were meant to provide the maximum level of malathion residues. Sprinkler irrigations were performed within one hour of each application, providing approximately 0.1 inch of water.

Field data were collected from June to September 1995. A total of twelve transferable residue samples and three control samples were collected from each site (three samples collected from a subplot in each of the four treated plots and a control plot at each site). At most locations, samples were collected before and after application, then at 4, 8, 12, 24, and 72 hours after treatment. Transferable residues of malathion were quantified by placing cloth dosimeters on the turf. A 15-kg roller was then rolled over each dosimeter. After being shaken to remove foliage, dosimeters were stored and shipped frozen to the laboratory for analysis. The malathion parent compound was the analyte measured. Field recovery and laboratory recovery data were collected; however, storage stability samples were not examined.

For the purposes of this occupational post-application exposure assessment, a regression analysis was conducted using the (log transformed) DFR data from this study to estimate residue levels after 4, 8, 12, 24, 48, and 72 hours after treatment using the following equation:

$$y = mx + b$$

where:

x = hours after treatment;
m = slope of the regression line;
b = constant; and
y = residue at hour x.

Regression and data analyses were conducted to examine the dissipation data and to compare with the results of the study report. A comparison of reported analytical residue values and regression analysis data is presented in Table 11. For the Pennsylvania site, the average residue level was 1.22 ug/cm$^2$ at 0 hour, and declined to 0.0110 ug/cm$^2$ at 72 hours after treatment. The half-life was 12.1 hours (r=0.925). For the North Carolina site, the average residue level was 0.297 $\mu$g/cm$^2$ at 0 hour, and declined to less than the LOQ at 48 hours after treatment. The half life was 11.2 hours (r=0.716). For the Missouri site, the average level was 0.605 $\mu$g/cm$^2$ at 0 hour, and declined to less than the LOQ at 72 hours after treatment. The half-life was 13.8 hours (r=0.773). For the California site, the average residue level was 0.815 ug/cm$^2$ at 0 hour, and declined to 0.0159 ug/cm$^2$ at 72 hours after treatment. The half-life was 14.5 hours (r=0.90).

The average coefficient of variability from each individual site ranged from 45.4 to 71.1 and suggested considerable data variability among treated plots. Coefficients of correlation ranged from 0.909 to 1.000. R square values for each regression model ranged from 0.827 to 1.000, and p-values for F statistics ranged from 0.0045 to 0.0890.

In summary, the transferable residue study completed in support of malathion only partially met the criteria contained in Subdivison K of the Pesticide Assessment Guidelines. The conclusion was based on the following issues of concern: (1) a considerable variability in the reported DFR residues reported in each site (e.g., the average coefficient of variability from each individual site ranged from 45.4% to 71.1%); (2) the label information was not provided in the study report, so it was not clear whether the maximum label rate of 5 lb ai per acre was appropriate. As identified in the handler section of this report, some malathion labels for turf products indicate a label rate of 8.7 lb ai per acre; (3) information as to the actual agricultural practices for turf (e.g, irrigation) were not identifiable because of the lack of label information; (4) the study samples were stored up to 14 days (from the day of sampling to the day of analysis); however, storage stability was not examined; (5) the study describes an irrigation practice which may cause an underestimation of the initial residue concentration; and (6) insufficient samples were collected at the North Carolina site; only 0, 4, 24, and 48 hour postapplication samples were collected, and a considerably large number of less-than-LOQ results were obtained, which may have been due to a significant rain event that ocurred shortly after application. It was concluded, however, that none of the above deficiencies was sufficient to preclude the use of the results from the turf study in this assessment.

The dissipation curve generated by the regression analysis of the measured values in the turf study allows for the prediction of DFR values beyond the period during which measurements were made and for application rates and crop activity transfer coefficients different from those for turf. The average half-life of malathion from the turf study was 13 hours. This corresponds to a 46% per day dissipation rate. DFRs were derived for harvesting and non-harvesting activities for other crops using appropriate default TCs and the 46% dissipation rate rather than the default 10% rate. Postapplication risks for turf used 1.3% of the application rate as the initial amount of residue available for transferring to skin, as predicted by the regression analysis based on the actual DFR value measured immediately after application (0 hour) in the turf study. For all other crop types, the HED standard default value for initial DFR (20%) was used.

**Table 11: Malathion Residues Following Application of Malathion 57EC at 5 lb ai/A to Turfgrass.**

| Hours after treatment | Pennsylvania Transferrable Residues (µg/cm$^2$) Reported [Predicted[a]] | North Carolina Transferrable Residues (µg/cm$^2$) Reported [Predicted[a]] | Missouri Transferrable Residues (µg/cm$^2$) Reported [Predicted[a]] | California Transferrable Residues (µg/cm$^2$) Reported [Predicted[a]] | Average Transferrable Residues (µg/cm$^2$) Reported [Predicted[a]] |
|---|---|---|---|---|---|
| 0 | 1.22 [0.648] | 0.297 [0.0596] | 0.605 [0.0880] | 0.815 [0.420] | 0.73 [0.30] |
| 4 | 0.424 [0.515] | 0.0131 [0.0465] | 0.0466 [0.0721] | 0.203 [0.347] | 0.17 [0.25] |
| 8 | ND [0.409] | ND [0.0363] | ND [0.0590] | 0.137 [0.286] | 0.137 [0.20] |
| 12 | 0.415 [0.325] | ND [0.0284] | 0.0244 [0.0483] | 0.536 [0.236] | 0.325 [0.16] |
| 24 | 0.0481 [0.163] | 0.00548 [0.0135] | 0.00760 [0.0265] | 0.112 [0.133] | 0.043 [0.084] |
| 48 | 0.0657 [0.041] | < LOQ [0.00305] | <LOQ [0.00799] | 0.0336 [0.0421 | 0.05 [0.024] |
| 72 | 0.0110 [0.0103] | ND [0.000691] | <LOQ [0.00241] | 0.0159 [0.0133] | 0.013 [0.0067] |
| Half-Life (hours) | 12.1 | 11.2 | 13.8 | 14.5 | 12.9 |

a Predicted transferrable residue (ug/cm$^2$) = Exp $^{(\text{intercept + slope x time})}$
ND No Data
<LOQ = Less than limit of quantitation.

### 2.2.3 Occupational Postapplication Exposure and Risk Assessment

The surrogate assessments presented in Table 12 are based on the application rates recommended for field crops, on maximum application rates from residue field trials in support of food tolerances and malathion labels, and on assumptions regarding activity levels. These assumptions would be expected to bracket the reentry exposure levels anticipated from maximum malathion labelled use rates on these crop types. The scenarios and assumptions addressed by the calculations are described below:

- Harvesting reentry activity (harvesting) associated with applications to crops for which there is potential for a high degree of dermal contact (e.g. tomatoes), and all reentry activities (hand-harvesting, pruning, shaking, propping,) associated with applications to tree crops (e.g., apples, pecans and other such fruit and nut crops) at an application rate of 6.0 lb ai/acre: Tc = 10,000 cm$^2$/hour;

- Non-harvesting reentry activity (scouting, hoeing, staking, tying, weeding) associated with applications to crops for which there is potential for a high degree of dermal contact (e.g., tomatoes) at an application rate of 6.0 lb ai/acre: Tc = 4000 cm$^2$/hour;

- Harvesting (harvesting) and non-harvesting reentry activities (scouting, hoeing, weeding) associated with applications to crops for which there is potential for a medium degree of dermal contact (e.g., strawberries) at an application rate of 4.0 and 0.5 lb ai/acre: Tc = 4000 $cm^2$/hour;
- Harvesting reentry activity (harvesting) associated with applications to crops for which there is potential for a low degree of dermal contact (e.g., asparagus, broccoli and soybeans) at an application rate of 4.0 and 0.5 lb ai/acre: Tc = 2,500 $cm^2$/hour;
- Non-harvesting reentry activity (scouting, hoeing, irrigating, weeding) associated with applications to crops for which there is potential for a low degree of dermal contact (e.g., asparagus, broccoli and soybeans) at an application rate of 4.0 and 0.5 lb ai/acre: Tc = 1000 $cm^2$/hour;
- Transplanting and pruning reentry activity associated with ornamental shrubs and trees at an application rate of 2.6 lb ai/acre: Tc = 10,000 $cm^2$/hour;
- Harvesting, hand girdling, caning, tieing, pruning, thinning, and tipping grapes at an application rate of 2.0 lb ai/acre: Tc = 15,000 $cm^2$/hour; and,
- Mowing and maintaining turfgrass at an application rate of 8.7 lb ai/acre: Tc = 1000 $cm^2$/hour.
- Cutting, rolling and harvesting sodgrass at an application rate of 8.7 lb ai/acre: Tc = 10,000 $cm^2$/hour.
- Cutting and harvesting reentry activity associated with applications to mushrooms at an application rate of 2 lb ai/acre: Tc = 2500 $cm^2$/hr.

The DFR is derived from the application rates for these crops, using an estimated 1.3 percent of the rate applied as initial dislodgeable residue for turf uses (based on predicted residue value at time 0 in the turf study), 20 percent of the rate for all other uses, and an estimated 46 percent dissipation rate per day (based on reported residue values from the turf study) for all uses. The equations used for the calculations in Table 12 are presented below:

$$DFR\left(\frac{\mu g}{cm^2}\right) = AR\left(\frac{lb\ ai}{acre}\right) \times CF\left(\frac{\mu g/cm^2}{lb\ ai/acre}\right) \times F \times (1 - DR)^t$$

Where:

| | | |
|---|---|---|
| DFR | = | Dislodgeable foliar residue ($\mu g/cm^2$), |
| AR | = | Application rate (6.0 lb ai/acre for fruit & nut (high dermal contact) crops; 4.0 and 0.5 lb ai/acre for medium and low dermal contact crops; 2 lb ai/acre for grapes and mushrooms; 2.6 lb ai/acre for ornamentals; and 8.7 lb ai/acre for turfgrass), |
| CF | = | Conversion factor (11.2 $\mu g/cm^2$ per lb ai/acre), |
| F | = | Fraction retained on foliage (1.3 percent for turf; 20 percent for all other uses), |
| DR | = | Daily dissipation rate (46 percent/day), |
| t | = | Days after treatment. |

$$Dose\ (mg/kg/day) = \frac{(DFR\ (\mu g/cm^2) \times Tc\ (cm^2/hr) \times CF\ (0.001\ mg/\mu g) \times ED\ (hr/day)) \times Abs\ (\%/100)}{BW\ (kg)}$$

Where:

| | | |
|---|---|---|
| Tc | = | Transfer coefficient ($cm^2$/hr, see assumptions above), |

CF = Conversion factor (0.001 mg/$\mu$g),
Abs = Absorption (10% dermal absorption; applies only to long-term exposure)
ED = Exposure duration (8 hours worked per day), and
BW = Body weight (70 kg).

$$MOE = \frac{NOEL\ (mg/kg/d)}{Dose\ (mg/kg/d)}$$

Where:
NOEL = 50 mg/kg/day (short and intermediate-term) or 4 mg/kg/day (long-term)
Dose = Calculated dose.

**Table 12: Malathion Short- and Intermediate-Term Surrogate Postapplication Assessment**

| DAT[a] | DFR ($\mu$g/cm$^2$)[b] | Dermal Dose (mg/kg/day)[c] | | MOE[d] | |
|---|---|---|---|---|---|
| | | Non-harvesting | Harvesting | Non-harvesting | Harvesting |
| Tree Crops with Potential for High Degree of Dermal Contact (at 6.0 lbs ai/acre) | | | | | |
| 0 | 13.5 | 6.15 | 15.37 | 8 | 3 |
| 1 | 7.26 | 3.32 | 8.30 | 15 | 6 |

| DAT[a] | DFR ($\mu$g/cm$^2$)[b] | Dermal Dose (mg/kg/day)[c] | | MOE[d] | |
|---|---|---|---|---|---|
| | | Non-harvesting | Harvesting | Non-harvesting | Harvesting |
| 2 | 3.9 | 1.79 | 4.48 | 28 | 11 |
| 3 | 2.1 | 0.97 | 2.42 | 52 | 21 |
| 5 | 0.6 | 0.28 | 0.71 | 177 | 71 |
| 6 | 0.3 | 0.15 | 0.38 | NA | 131 |
| Crops with Potential for Medium Degree of Dermal Contact (at 4.0 lbs ai/acre) | | | | | |
| 0 | 9.0 | 4.10 | same | 12 | same |
| 1 | 4.84 | 2.21 | same | 23 | same |
| 2 | 2.6 | 1.20 | same | 42 | same |
| 3 | 1.4 | 0.65 | same | 77 | same |
| 4 | 0.8 | 0.35 | same | 143 | same |
| Crops with Potential for Medium Degree of Dermal Contact (at 0.5 lbs ai/acre) | | | | | |
| 0 | 1.1 | 0.51 | same | 98 | same |
| 1 | 0.61 | 0.28 | same | 181 | same |
| Crops with Potential for Low Degree of Dermal Contact (at 4.0 lbs ai/acre) | | | | | |
| 0 | 9.0 | 1.02 | 2.56 | 49 | 20 |
| 1 | 4.84 | 0.55 | 1.38 | 90 | 36 |
| 2 | 2.6 | 0.30 | 0.74 | 167 | 67 |
| 3 | 1.4 | 0.16 | 0.40 | NA | 124 |
| Crops with Potential for Low Degree of Dermal Contact (at 0.5 lbs ai/acre) | | | | | |
| 0 | 1.1 | 0.012 | 0.32 | 390 | 156 |
| Transplanting/pruning Ornamental Trees and Shrubs (at 2.6 lbs ai/acre) | | | | | |
| 0 | 5.8 | 6.66 | NA | 8 | NA |
| 1 | 3.15 | 3.60 | NA | 14 | NA |
| 2 | 1.7 | 1.94 | NA | 26 | NA |
| 3 | 0.9 | 1.05 | NA | 48 | NA |
| 4 | 0.5 | 0.57 | NA | 88 | NA |
| 5 | 0.3 | 0.31 | NA | 163 | NA |
| Harvesting, Girdling, Caning, Tieing, Pruning, Thinning and Tipping Grapes (at 2.0 lbs ai/acre) | | | | | |
| 0 | 4.5 | 7.69 | same | 7 | same |
| 1 | 2.42 | 4.15 | same | 12 | same |
| 2 | 1.3 | 2.24 | same | 22 | same |
| 3 | 0.7 | 1.21 | same | 41 | same |

| DAT[a] | DFR ($\mu$g/cm$^2$)[b] | Dermal Dose (mg/kg/day)[c] | | MOE[d] | |
|---|---|---|---|---|---|
| | | Non-harvesting | Harvesting | Non-harvesting | Harvesting |
| 4 | 0.4 | 0.65 | same | 77 | same |
| 5 | 0.2 | 0.36 | same | 142 | same |
| Maintaining and Harvesting Turfgrass (at 8.7 lbs ai/acre) | | | | | |
| 0 | 1.3 | 0.14 | 1.45 | 345 | 35 |
| 1 | 0.7 | 0.08 | 0.78 | NA | 64 |
| 2 | 0.4 | 0.04 | 0.42 | NA | 118 |
| Cutting and Harvesting Mushrooms (at 2.0 lbs ai/acre) | | | | | |
| 0 | 4.5 | 1.28 | same | 39 | same |
| 1 | 2.42 | 0.69 | same | 72 | same |
| 2 | 1.3 | 0.37 | same | 134 | same |

a DAT is "days after treatment."
b Initial DFR = Application Rate x Conversion Factor (11.209 $\mu$g/cm$^2$ lb ai/acre) x Fraction of initial ai retained on foliage (1.3% for turf; 20% for other uses) x (1- daily dissipation rate (46%)$^{time}$.
c Dose (mg/kg/day)= [DFR (ug/cm$^2$) x Tc (cm$^2$/hr) x Conversion factor (1 mg/1000 µg) x hrs worked per day (hrs)]/Body Weight (kg);
d MOE = NOEL (mg/kg/day)/Dose (mg/kg/day); where NOEL is 50 mg/kg/day based on a dermal study.

NA= Not Applicable. MOE already exceeds 100

### 2.2.4 Summary of Occupational Postapplication Risk, Data Gaps and Confidence in Exposure and Risk Estimates

**Short- and Intermediate-Term Risk**

The target MOE is 100 for malathion. The resulting short- and intermediate-term surrogate occupational postapplication assessment for malathion, indicates that:

- MOEs equal or exceed 100 for harvesting activities associated with crops for which there is potential for a high degree of dermal contact (e.g., tomatoes), and for all reentry activities associated with applications to tree crops on the **6 th day** following application at a rate of 6.0 pounds active ingredient per acre. Tc = 10,000 $cm^2$/hr

- MOEs equal or exceed 100 for non-harvesting reentry activities associated with applications to crops for which there is potential for a high degree of dermal contact (e.g., tomatoes) on the **5th day** following application at a rate of 6.0 lb ai/acre: Tc = 4000 $cm^2$/hour;

- MOEs equal or exceed 100 for harvesting and non-harvesting reentry activities associated with applications to crops for which there is potential for a medium degree of dermal contact (e.g., strawberries) on the **4th day** following application at a rate of 4.0 lb ai/acre: Tc = 4000 $cm^2$/hour;

- MOEs equal or exceed 100 for harvesting and non-harvesting reentry activities (scouting, hoeing, weeding) associated with applications to crops for which there is potential for a medium degree of dermal contact (e.g., strawberries) on the **1st day** following application at a rate of 0.5 lb ai/acre: Tc = 4000 $cm^2$/hour;

- MOEs equal or exceed 100 for harvesting reentry activities associated with applications to crops for which there is potential for a low degree of dermal contact (e.g., asparagus, broccoli and soybeans) on the **3rd day** following application at a rate of 4.0 lb ai/acre (Tc = 2,500 $cm^2$/hour); and for non-harvesting activities on the **2nd day** (Tc = 1000 $cm^2$/hour).

- MOEs equal or exceed 100 for harvesting (Tc = 2,500 $cm^2$/hour) and non-harvesting (Tc = 1000 $cm^2$/hour) reentry activities associated with applications to crops for which there is potential for a low degree dermal contact (e.g., asparagus, broccoli and soybeans) on the **same day** following application at a rate of 0.5 lb ai/acre;

- MOEs equal or exceed 100 for transplanting and pruning reentry activities associated with ornamental shrubs and trees on the **5th day** following application at a rate of 2.6 lb ai/acre: Tc = 10,000 $cm^2$/hour;

- MOEs equal or exceed 100 for harvesting, hand girdling, caning, pruning, thinning, and tipping grapes on the **5th day** following application at a rate of 2.0 lb ai/acre: Tc = 15,000 $cm^2$/hour;

- MOEs equal or exceed 100 for mowing and maintaining turfgrass on the **same day** following application at a rate of 8.7 lb ai/acre: Tc = 1000 $cm^2$/hour.

- MOEs equal or exceed 100 for cutting, rolling and harvesting sodgrass on the **2nd day** following application at a rate of 8.7 lb ai/acre: Tc = 10,000 $cm^2$/hour.

- MOEs equal or exceed 100 for cutting and harvesting reentry activities associated with applications to mushrooms on the **2nd day** following application at a rate of 2 lb ai/acre: Tc = 2500 $cm^2$/hr.

Based on the occupational postapplication risks determined by the surrogate agricultural assessment, reentry is of concern on the same day as application (12 hours following treatment) for all exposure scenarios except for non-harvesting activities associated with crops for which there is potential for a low degree of dermal contact (e.g., asparagus, broccoli and

soybeans) at the 0.5 lb ai/acre rate, and for all reentry activities associated with mowing and maintaining turfgrass. Because crops treated with malathion have an existing REI of 12 hours, HED has a concern over occupational short-term occupational postapplication risk.

**Chronic Risk**

The only chronic occupational postapplication scenario is for handling mushrooms (cutting, harvesting, sorting and packing) from beds that have been treated with malathion. It is assumed that a worker is engaged in such work for 180 days per year. The long-term endpoint is a 4 mg/kg/day NOAEL from a from a two-year feeding study. A dermal equivalent dose (using a 10% dermal absorption factor) of 40 mg/kg/day was used in the calculation. The resulting chronic surrogate postapplication assessment for malathion indicates that:

- MOEs equal or exceed 100 (i.e., 108) for harvesting activities associated with applications to mushrooms on the **2nd day** following application at a rate of 2.0 lb ai/acre: Tc = 2500 $cm^2$/hr. [Note that this is the same as for the short and intermediate risks]

Based on the occupational postapplication risks determined by the surrogate agricultural assessment, reentry is of concern on the same day as application (12 hours following treatment) for all exposure scenarios except for non-harvesting activities associated with crops for which there is potential for a medium degree of dermal contact at the 0.5 lb ai/acre rate; non-harvesting activities associated with crops for which there is a low degree of dermal contact (e.g., asparagus, broccoli and soybeans) at the 0.5 lb ai/acre rate, and for activities associated with mowing and maintaining turfgrass. Because crops treated with malathion have an existing REI of 12 hours, HED has a concern over occupational postapplication risk.

**Data Gaps**

The surrogate assessment was performed with a 46% daily dissipation rate. The usual estimate used in the surrogate assessment, when no other postapplication information is available is a 10% daily dissipation rate. This is based on the average half-life calculated from the actual transferrable residue data measured at all four sites in the turf study. Likewise, the initial amount of residue available to be transferred from turf to workers (i.e., 1.3% of application rate) was based on the average amount of transferrable residue found immediately following application of malathion in the turf study. Even though these variables were derived from a transferrable residue study with turf, they are believed to be more appropriate and directly applicable to predicting DFR values for other crops than using standard HED default assumptions of 20% of application rate as initially available residue, and a 10% per day dissipation rate. Field studies to determine dislodgeable foliar residues on a variety of crops treated by malathion would be necessary to refine the postapplication risk.

## 3.0 RESIDENTIAL AND OTHER NON-OCCUPATIONAL EXPOSURES AND RISKS

### 3.1 Residential Handler Exposures and Risks

EPA has determined that residential and other non-occupational handlers are likely to be exposed during malathion use. The anticipated use patterns and current labeling indicate several major exposure scenarios, based on the types of equipment that potentially can be used to make malathion applications. These scenarios include:

(1a) mixing/loading/applying liquid with a low pressure handwand;
(1b) mixing/loading/applying wettable powder with a low pressure handwand;
(2) mixing/loading/applying liquid with a hose end sprayer;
(3) mixing/loading/applying liquid with a backpack sprayer;
(4) mixing/loading/applying liquid with a fogger; and
(5) mixing/loading/applying dust using a shaker can.

#### 3.1.1 Residential Handler Exposure Scenarios - Data and Assumptions

Residential handler exposure assessments were completed by HED assuming a "baseline" exposure scenario (for homeowners, short sleeved shirt, short pants, shoes and socks, and no gloves or respirator). PHED values used to estimate daily unit exposure values were taken from the *Standard Operating Procedures (SOPs) for Residential Exposure Assessments (December 1997)*.[8] Table 15 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment. The following assumptions and factors were used in order to complete this exposure assessment:

- Calculations were completed at the maximum application rates for specific crops recommended by the available malathion labels to cover the range of maximum risk levels associated with various use patterns. No use data were provided by the registrant concerning the actual application rates that are commonly used for malathion, though survey data indicates that it is common for homeowners to apply maximum rates.

- The duration of exposure is expected to be short-term (1-7 days) based on label directions for multiple applications of malathion to fruits, vegetables, ornamentals, lawns, and outdoor premises which may be made every 7 days "as necessary". The frequency of homeowner applications is not expected to result in a continuous exposure duration of 1 week to several months. None of the currently registered residential or other non-occupational uses would result in long-term exposures.

- Generally, the use of PPE and engineering controls are not considered acceptable options for products sold for use by homeowners.

- For the low pressure handwand and the backpack sprayer, an estimate of 5 gallons of spray per day for fruit trees, ornamentals, vegetable/small fruit gardens, and mosquitoes was used for the homeowner scenario.

- For the low pressure handwand, backpack sprayer, and hose end sprayer an estimate of 1,000 $ft^2$ was used for spot treatment of homeowner turf.

- For the hose end sprayer, an estimate of 5 gallons of spray per day for fruit trees, ornamentals, vegetable/small fruit gardens, and mosquitoes was used for the homeowner scenario.

#### 3.1.2 Residential Handler Exposure and Risk Estimates

The calculations of daily dermal and inhalation exposure to malathion by handlers was used to calculate the daily dose, and hence the risks, to those handlers. Potential daily dermal exposure was calculated using the following formula:

$$Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{day}\right) = Unit\ Exposure\left(\frac{mg\ ai}{lb\ ai}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A dermal absorption value was not needed for short- and intermediate-term dermal exposure because the dermal NOAEL was based on a 21-day dermal study; however, because the long-term (chronic) risks are based on a feeding study, the use of a dermal absorption factor (10%) was determined to be appropriate for the calculation.

Potential daily inhalation exposure was calculated using the following formula:

$$Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) =$$
$$Unit\ Exposure\left(\frac{\mu g\ ai}{lb\ ai}\right) x\ Conversion\ Factor\left(\frac{1mg}{1{,}000\ \mu g}\right) x\ Use\ Rate\left(\frac{lb\ ai}{A}\right) x\ Daily\ Acres\ Treated\left(\frac{A}{day}\right)$$

A 100 percent inhalation absorption value is assumed.

The daily dermal and inhalation dose was calculated using a 70 kg body weight for all toxicity endpoints (i.e., short-term, intermediate-term and chronic) exposure as follows:

$$Daily\ Inhalation\ Dose\left(\frac{mg\ ai}{kg/day}\right) = Daily\ Inhalation\ Exposure\left(\frac{mg\ ai}{day}\right) x\left(\frac{1}{Body\ Weight\ (kg)}\right)$$

$$Daily\ Dermal\ Dose\left(\frac{mg\ ai}{Kg/Day}\right) = Daily\ Dermal\ Exposure\left(\frac{mg\ ai}{Day}\right) x\left(\frac{1}{Body\ Weight\ (Kg)}\right)$$

The calculations of both the daily dermal dose and the daily inhalation dose of malathion received by handlers was used to calculate the short-term dermal and inhalation MOEs. The dermal MOE was calculated using a NOAEL of 50 mg/kg/day, and the inhalation MOE was calculated using a NOAEL of 25.8 mg/kg/day. The following formula describes the calculation of a dermal MOE:

$$Dermal\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Dermal\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The following formula describes the calculation of an inhalation MOE:

$$Inhalation\ MOE = \frac{NOEL\left(\frac{mg}{kg/day}\right)}{Inhalation\ Daily\ Dose\left(\frac{mg}{kg/day}\right)}$$

The target dermal MOE, including short-, intermediate and long-term exposure periods, is 100. The target inhalation MOE, including short-, intermediate and long-term exposure periods, is 1000. Chronic exposure is not expected for handlers, and therefore is not assessed. The short- and intermediate-term toxicity endpoint is the same (i.e., cholinesterase inhibition) for both dermal and inhalation exposure. Because the effect of concern is the same, the exposure contributed from both dermal and inhalation routes are added together. However, since the target MOEs are different for dermal (100) and inhalation (1000) exposure, the total risk is estimated by an Aggregate Risk Index (ARI). In order for the MOEs to be combined, there must be a common target MOE. If the MOE/Target MOE ratios for each route are treated as fractions, they can be adjusted to a common denominator of 1. This results in an ARI for dermal and an ARI for inhalation.

In order to calculate a Total ARI, the reciprocals of the dermal and inhalation ARIs are combined and divided into 1. The above operations are represented as follows:

$ARI_{dermal}$ = calculated dermal MOE ÷ target MOE (100)

$ARI_{inhalation}$ = calculated inhalation MOE ÷ target MOE (1000)

$$\text{Total ARI} = \frac{1}{\frac{1}{ARI_{dermal}} + \frac{1}{ARI_{inhalation}}}$$

A total ARI $\geq$ 1 in general, does not present a concern for handler exposure.

Residential dermal and inhalation exposures (developed using PHED Version 1.1 surrogate data) are presented in Table 13. The corresponding short-term risks are presented in Table 14. Table 15 presents the residential scenario descriptions used in this RED.

**Table 13. Residential Handler Short-term Dermal and Inhalation Exposures to Malathion at Baseline.**

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Maximum Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Mixer/Loader/Applicator Exposure | | | | | | | |
| Mixing/Loading/Applying Liquids with a Low Pressure Handwand (1a) | 100 | 30 | 0.034 lb ai /gal | Fruit Tree | 5 gallons | 17 | 0.005 |
| | | | 0.034 lb ai /gal | Ornamentals | 5 gallons | 17 | 0.005 |
| | | | 0.18 lb ai /1000 sq. ft | Turf | 1,000 $ft^2$ | 18 | 0.005 |
| | | | 0.023 ai lb/gal | Vegetable/Small fruit Garden | 5 gallons | 11 | 0.003 |
| | | | 0.1547 lb ai /gal | Mosquitoes (household pests) | 5 gallons | 77 | 0.023 |
| Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b) | 250 | 1,100 | 0.010 lb ai /gal | Fruit Tree | 5 gallons | 13 | 0.055 |
| | | | 0.015 lb ai /gal | Ornamentals | 5 gallons | 19 | 0.083 |
| | | | 0.018 lb ai /gal | Vegetable/Small fruit Garden | 5 gallons | 23 | 0.099 |
| Mixing/Loading/Applying Liquids with a Hose End Sprayer (2) | 30 | 9.5 | 0.034 lb ai /gal | Fruit Tree | 5 gallons | 5.1 | 0.002 |
| | | | 0.034 lb ai /gal | Ornamentals | 5 gallons | 5.1 | 0.002 |
| | | | 0.18 lb ai /1000 sq. ft | Turf | 1,000 $ft^2$ | 0.54 | 0.000 |
| | | | 0.023 lb ai /gal | Vegetable/Small fruit Garden | 5 gallons | 3.5 | 0.001 |
| | | | 0.1547 lb ai/gal | Mosquitoes (household pests) | 5 gallons | 23 | 0.007 |

| Exposure Scenario (Scen. #) | Baseline Dermal Unit Exposure[a] (mg/lb ai) | Baseline Inhalation Unit Exposure[b] ($\mu$g/lb ai) | Maximum Application Rates[c] (lb ai/acre) | Crop Type or Target[d] | Amount Handled per Day[e] | Daily Dermal Exposure[f] (mg/day) | Daily Inhalation Exposure[g] (mg/day) |
|---|---|---|---|---|---|---|---|
| Mixing/Loading/Applying Liquids with Backpack Sprayer (3) | 5.1 | 30 | 0.034 lb ai/gal | Fruit Tree | 5 gallons | 0.87 | 0.005 |
| | | | 0.034 lb ai /gal | Ornamentals | 5 gallons | 0.87 | 0.005 |
| | | | 0.18 lb ai /1000 sq. ft | Turf | 1,000 $ft^2$ | 0.92 | 0.005 |
| | | | 0.023 lb ai /gal | Vegetable/Small fruit Garden | 5 gallons | 0.59 | 0.003 |
| | | | 0.16 lb ai /gal | Mosquitoes (household pests) | 5 gallons | 3.9 | 0.023 |
| Mixing/Loading/Applying Liquids with a Fogger (4) | No Data | No Data | 0.012 lb ai/gal | Mosquitoes (household pests) | No Data | No Data | No Data |
| Mixing/Loading/Applying Dust using a Shaker Can (5) | Note[1] | Note[1] | 0.046lb ai/1000 sq. ft | Ornamentals | 1000 $ft^2$ | 2100 | Note[1] |
| | | | 0.10 lb ai /1000 sq. ft | Turf | 1000 $ft^2$ | 4600 | |
| | | | 0.057 lb ai/1000 sq. ft | Vegetable/Small fruit Garden | 1000 $ft^2$ | 2600 | |

**Footnotes:**

a Baseline dermal unit exposure represents short pants, short sleeved shirt, no gloves, and open mixing/loading. Standard Operating Procedures (SOPs) for Residential Exposure Assessments - Draft. May 1997.

b Baseline inhalation unit exposure represents no respirator. Standard Operating Procedures (SOPs) for Residential Exposure Assessments - Draft. December 1997.

c Application rates are based on maximum application rates listed on the July 1997 LUIS report and malathion homeowner labels. EPA Reg. Nos. 239-739 (50%EC), 239-568 (7.5% WP), 829-61 (5% dust)

d Crop types or targets are selected from EPA guidance.

e Amount handled per day are from EPA estimates of acres treated, gallons applied, or square feet treated.

f Daily Dermal Exposure (mg/day) = Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).

g Daily Inhalation Exposure (mg/day) = Inhalation Unit Exposure ($\mu$g/lb ai) x (1 mg/1,000 $\mu$g) Conversion x Application rate (lb ai/acre; lb/gal; and ai/sq ft) x Amount Handled per day (acres, gallons, sq. ft.).

Note[1] No PHED data are available for this scenario. Draft SOPs for Residential Exposure Assessment (December 1997) include an assumption that the residential handler is exposed (dermal and inhalation) to 10% of the active ingredient applied by shaker can. When this assumption is used for only the dermal endpoint, the resulting MOEs are sufficiently low as to not warrant further analyses. (see Table 14 for MOEs)

**Table 14: Residential Handler Short-term Risks to Malathion at Baseline.**

| Exposure Scenario (Scen. #) | Crop Type or Target | Baseline Dermal Dose (mg/kg/day)[a] | Baseline Inhalation Dose (mg/kg/day)[b] | Baseline Dermal MOE[c] (UF=100) | Baseline Inhalation MOE[d] (UF=1000) | Baseline Total Aggregate Risk Index (ARI)[e] |
|---|---|---|---|---|---|---|
| Mixer/Loader/Applicator Exposure | | | | | | |
| Mixing/Loading/Applying Liquid with a Low Pressure Handwand (1a) | Fruit Trees | 0.24 | 0.00007 | 210 | 350,000 | 2.1 |
| | Ornamentals | 0.24 | 0.00007 | 210 | 350,000 | 2.1 |
| | Turf | 0.26 | 0.00007 | 190 | 350,000 | 1.9 |
| | Vegetable/Small Fruit Garden | 0.16 | 0.00004 | 300 | 660,000 | 3.0 |
| | Mosquitoes (household pests) | 1.11 | 0.00033 | 45 | 530,000 | 0.5 |
| Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b) | Fruit Trees | 0.18 | 0.00079 | 280 | 33,000 | 2.6 |
| | Ornamentals | 0.27 | 0.0012 | 190 | 22,000 | 1.7 |
| | Vegetable/Small Fruit Garden | 0.32 | 0.0014 | 160 | 18,000 | 1.4 |
| Mixing/Loading/Applying Liquids with a Hose End Sprayer (2) | Fruit Trees | 0.07 | 0.00002 | 690 | 110,000 | 7.0 |
| | Ornamentals | 0.07 | 0.00002 | 690 | 110,000 | 7.0 |
| | Turf | 0.01 | 0.00000 | 6300 | 1,300,000 | 60 |
| | Vegetable/Small Fruit Garden | 0.05 | 0.00002 | 1000 | 220,000 | 10 |
| | Mosquitoes (household pests) | 0.33 | 0.0001 | 150 | 160,000 | 1.5 |

| Exposure Scenario (Scen. #) | Crop Type or Target | Baseline Dermal Dose (mg/kg/day)[a] | Baseline Inhalation Dose (mg/kg/day)[b] | Baseline Dermal MOE[c] (UF=100) | Baseline Inhalation MOE[d] (UF=1000) | Baseline Total Aggregate Risk Index (ARI)[e] |
|---|---|---|---|---|---|---|
| Mixing/Loading/Applying Liquids with a Backpack Sprayer (3) | Fruit Tree | 0.01 | 0.00007 | 5000 | 350,000 | 50 |
| | Ornamentals | 0.01 | 0.00007 | 5000 | 350,000 | 50 |
| | Turf | 0.01 | 0.00007 | 5000 | 350,000 | 50 |
| | Vegetable/Small Fruit Garden | 0.01 | 0.00004 | 5000 | 650,000 | 50 |
| | Mosquitoes (household pests) | 0.06 | 0.00033 | 887 | 530,000 | 9 |
| Mixing/Loading/Applying Liquids with a Fogger (4) | Mosquitoes | Note[1] | Note[1] | Note[1] | Note[1] | Note[1] |
| Mixing/Loading/Applying Dust using a Shaker Can (5) | Ornamentals | 30.00 | Note[2] | 2 | Note[2] | Note[2] |
| | Turf | 65.00 | Note[2] | <1 | | |
| | Vegetable/Small Fruit Garden | 37.00 | Note[2] | 1 | | |

**Footnotes:**

a Baseline Dermal Dose (mg/kg/day) = Daily Dermal Exposure (mg/day) / Body Weight (70 kg).
b Baseline Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day) / Body Weight (70 kg).
c Baseline Dermal MOE = NOEL (50 mg/kg/day) / Baseline Dermal Dose (mg/kg/day).
d Baseline Inhalation MOE = NOEL (25.8 mg/kg/day) / Baseline Inhalation Dose (mg/kg/day).
e Total ARI (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE/Target Dermal MOE (100)) + (1/Calculated Inhalation MOE/Target Inhalation MOE (1000))).

Note[1] No PHED data are available for this scenario. However, it is believed that the scenario for mixing/loading and applying liquid for backpack sprayer application to control mosquitos serves as a comparable, if not worst case, surrogate for the use of a small fogger unit (based on EPA Reg. No. 769-844).

Note[2] No PHED data are available for this scenario. Draft SOPs for Residential Exposure Assessment (December 1997) include an assumption that the residential handler is exposed (dermal and inhalation) to 10% of the active ingredient applied by shaker can. When this assumption is used for only the dermal endpoint, the resulting MOEs are sufficiently low as to not warrant further analyses.

**Table 15: Residential Exposure Scenario Descriptions for the Use of Malathion**

| Exposure Scenario (Number) | Data Source | Standard Assumptions[a] | Comments[b] |
|---|---|---|---|
| Mixer/Loader/Applicator Descriptors | | | |
| Mixing/Loading/Applying Liquid with a Low Pressure Handwand (1a) | SOPs for Residential Exposure Assessments (12/97) | 5 gallons for small vegetable gardens, mosquitoes (household pests), fruit trees and ornamentals; and 1,000 $ft^2$ for spot-treatment of turf | **Baseline**: Dermal and inhalation data = ABC grades, and hands data = All grade. Dermal = 9-80 replicates; hands = 70 replicates; and inhalation = 80 replicates. Low confidence in hands, dermal data. Medium confidence in inhalation data.<br><br>**PPE and Engineering Controls**: Not feasible for assessment. |
| Mixing/Loading/Applying Wettable Powder with a Low Pressure Handwand (1b) | SOPs for Residential Exposure Assessments (12/97) | 5 gallons for small vegetable gardens, mosquitoes (household pests), fruit trees, and ornamentals | **Baseline:** Dermal and inhalation data = C grades, and hands data = A grade. Dermal = 16 replicates; hands = 15 replicates; and inhalation = 16 replicates. Low/medium confidence in hands and dermal data. Medium confidence in inhalation data.<br><br>**PPE and Engineering Controls: Not feasible for assessment.** |
| Mixing/Loading/Applying Liquid With a Hose-end Sprayer (2) | SOPs for Residential Exposure Assessments (12/97) | 5 gallons on trees, ornamentals and small vegetable gardens; and 1,000 $ft^2$ for spot-treatment of turf | **Baseline**: Dermal and inhalation = C grade, and hands = E grade. Dermal, inhalation, and hands = 8 replicates each. Low confidence in all data.<br><br>**PPE and Engineering Controls**: Not feasible for assessment. |
| Mixing/Loading/Applying Liquid Using a Backpack Sprayer (3) | SOPs for Residential Exposure Assessments (12/97) | 5 gallons on fruit/nut trees, ornamentals, and small vegetable gardens; and 1,000 $ft^2$ for spot-treatment of turf | **Baseline**: Dermal = AB grade; inhalation = A grade; and hands = C grade. Dermal = 9 to 11 replicates; hands = 11 replicates; and inhalation = 11 replicates. Low confidence in dermal, hands, and inhalation data. A 90% protection factor was used to backcalculate "no glove" hand data from the gloved scenario.<br><br>**PPE and Engineering Controls**: Not feasible for assessment. |
| Mixing/Loading/Applying Liquid with a Fogger (4) | See Comments | See Comments | No PHED Data. However, it is believed that the scenario for mixing/loading and applying liquid for backpack sprayer application to control mosquitos serves as a comparable, if not worst case, surrogate for the use of a small fogger unit (based on EPA Reg. No. 769-844). |
| Loading/Applying Dust Using a Shaker Can (5) | See Comments | See Comments | No PHED Data. However, Draft SOPs for Residential Exposure Assessment (December 1997) include an assumption that the residential handler is exposed (dermal and inhalation) to 10% of the active ingredient applied by shaker can. This assumption is used for estimating dermal MOEs. |

[a] Standard Assumptions based on HED estimates.

[b] "Best Available" grades are defined by HED SOP for meeting Subdivision U Guidelines (Series 875 - Group A). Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

### 3.1.3 Summary of Risk for Non-Occupational Handlers, Data Gaps, and Confidence in Exposure and Risk Estimates

Dermal short- and intermediate-term risks below were calculated using the same toxicity endpoint (NOAEL = 50 mg/kg/day). A chronic risk assessment was not conducted as the HED believes that malathion residential use patterns do not lend themselves to chronic exposure. A summary of risk assessment results is reported below.

**Short- and Intermediate-term Residential Handler Risks**

The calculations of short- and intermediate-term total risks indicate that the **ARI is equal to, or greater than 1** for the following scenarios:

- (1a) mixing/loading/applying liquid with a low pressure handwand (fruit trees, ornamentals, turf and vegetable/small fruit garden).
- (1b) mixing/loading/applying wettable powder with a low pressure handwand (fruit trees,ornamentals and vegetable/small fruit garden).
- (2) mixing/loading/applying with a hose end sprayer (fruit trees, ornamentals, turf, vegetable/small fruit garden, and mosquitoes).
- (3) mixing/loading/applying with a backpack sprayer (fruit trees, ornamentals, turf, vegetable/small fruit garden, and mosquitoes).
- (5) mixing/loading/applying dust using a shaker can (ornamentals, turf, and vegetable/small fruit garden). This assumes that risk is equivalent to that for scenario (1b).

The calculations of short- and intermediate-term total risks indicate that the **ARI is not equal to, or greater than 1** for the following scenarios:

- (1a) mixing/loading/applying liquid with a low pressure handwand (mosquitoes/ household pests).

**Data Gaps**. The following data gaps exist for the following scenarios:

- (4) mixing/loading/applying with a fogger (mosquitoes).
- (5) mixing/loading/applying dust using a shaker can (ornamentals, turf, and vegetable/small fruit garden). Risk for this scenario is assumed to be equivalent to that for scenario (1b).

**Data Quality and Confidence in Assessment.** Several issues must be considered when interpreting the homeowner handler risk estimates:

- Several handler assessments were completed using “low quality” PHED data due to the lack of a more acceptable dataset.
- Several generic protection factors were used to calculate handler exposures. These protection factors have not been completely evaluated and accepted by HED.
- Factors used to calculate daily exposures to handlers (e.g., square feet treated per day and gallons of liquid applied) are based on the best professional judgement.

- PHED data were from estimates found in the *Standard Operating Procedures (SOPs) for Residential Exposure Assessments (December 1997)*.[8]

### 3.2 Non-occupational Postapplication Exposures and Risks

EPA has determined that there are potential post-application exposures to residents contacting treated lawns, contacting residues on turf at home and in public areas from aerial or ground public mosquito control and spray drift from agricultural applications in nearby fields, performing work in treated vegetable gardens, harvesting from fruit and nut trees, pruning or thinning ornamental trees or shrubs and harvesting strawberries in commercial "pick-your-own" fields. While other scenarios, such as exposure on golf courses are also possible, the ones chosen here are the most common exposure scenarios and the ones most likely to bracket the overall risk. Also, it should be noted that the inhalation component of post-application exposure is usually negligible in comparison to the contribution of dermal exposure, and is therefore, not included in most determinations of postapplication risk. However, because of the widespread aerial and truck-fogger application of malathion in public mosquito-vector control, a postapplication inhalation exposure scenario is discussed separately in a later section. Also, and separate evaluation of spray drift from the USDA Boll Weevil Eradication Program is presented.

#### 3.2.1 Postapplication Exposure Scenarios, Data, and Assumptions

The scenarios likely to result in postapplication exposures are listed in Table 16 and are as follows:

- Dermal exposure from residues on vegetable/small fruit gardens;
- Dermal exposure from residues on fruit trees and ornamentals;
- Dermal exposure from "pick your own" strawberries;
- Dermal exposure from residues on residential, park and school playground sites due to aerial and ground mosquito abatement applications.(adult and toddler);
- Dermal exposure from residues on treated residential turf (adult and toddler);
- Incidental nondietary ingestion of residues on lawn (residential, park and school playground) from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (residential, park and school playground) (toddler); and
- Incidental ingestion of soil from treated areas (residential, park and school playground) (toddler).

Because of the unique circumstances regarding the special uses of malathion in public health mosquito abatement control and the USDA's Boll Weevil Eradication Program, the inhalation exposure from ground and aerial mosquito abatement applications (adult and toddler), as well as, dermal and inhalation exposure to residential bystanders from aerial application of malathion for the USDA Boll Weevil Eradication Program, are assessed separately in sections to follow.

#### 3.2.2 Basis and Approach for Assessment of Postapplication Scenarios

A transferable residue study on turf (MRID 441133-01) was conducted with malathion formulated as the end use product Malathion 57EC. This study examined the residue levels of malathion that could be transferred from treated turf. A description of this study appeared earlier under section 2.2.2. In this

current section on non-occupational post-application exposure, the results of that turf study are used in the same manner as was made for occupational postapplication assessement. The dissipation curve generated by the regression analyis of the measured values in the turf study allows for the prediction of DFR values for all of the aforementioned non-occupational exposure scenarios. The average half-life of malathion from the turf study was 13 hours. This corresponds to a 46% per day dissipation rate. DFRs were derived for harvesting and non-harvesting activities for other crops using appropriate default TCs and the 46% dissipation rate rather than the default 10% rate. Postapplication risks involving contact with turf were based on an intial amount of residue available to transfer to the skin predicted by the regression analysis (i.e., 1.3% of the application rate) which included the actual DFR value measured immediately after application (0 hour) in the turf study. For activities involving contact with other crops, the HED standard default value for the amount of residue initially available to transfer to skin (i.e., 20% of the application rate) was used.

HED has determined that there are potential post-application exposures to adults and children contacting residues on turf resulting from public mosquito control uses. Potential exposures are estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) aerial and ground-based fogger applications in the vicinity of residential dwellings. The assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in other recreational areas (e.g., school playgrounds, parks, athletic fields). The scenarios likely to result in post-application exposures are follows:

- Dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- Incidental nondietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (toddler); and
- Incidental ingestion of soil from treated areas (toddler).

As mentioned earlier, inhalation of malathion in the immediate vicinity and in the same time frame as ULV ground-based fogging or aerial ULV operations may result in inhalation exposure. While not considered to be a major contributor to the hazard, an estimate of the risk from this potential exposure is also given.

Chemical-specific data for mosquito uses have not been submitted by the registrant. Therefore, the equations and assumptions used for each of the scenarios were derived from airborne exposure models, and taken from published literature studies and the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document. A description of the literature studies, the model and the assumptions and equations are provided below.

Ground-based ULV

In the study conducted by Moore *et al.,* [*Downwind Drift and Deposition of Malathion on Human Targets From Ground Ultra-Low Volume Mosquito Sprays*: J.C. Moore, J.C. Dukes, J.R. Clark, J. Malone, C.F. Hallmon, and P.G. Hester; Journal of the American Mosquito Control Association; Vol. 9, No. 2 (June, 1993)] both human exposure and deposition was quantified over 5 separate application

events. A 91 percent formulation of malathion was applied in April and May of 1989 in the early evening (a time of day for relative atmospheric stability). A Leco HD ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.05 lb ai/acre (i.e., equates to a deposition rate of 0.51 $\mu g/cm^2$). Deposition was monitored at three locations downwind from the treatment area (i.e., 15.2 m, 30.4 m, and 91.2 m). For the events considered in the deposition calculations, "average amounts of malathion deposited on ground level at 15.2, 30.4, and 91.2 m were not significantly different." The percentage of the application rate reported to have deposited ranged from 1 to 14 percent. The mean deposition value for all measurements was 4.3 percent (n=35, CV=98).

In the study conducted by Tietze *et al.,* [*Mass Recovery of Malathion in Simulated Open Field Mosquito Adulticide Tests*: N.S. Tietze, P.G. Hester, and K.R. Shaffer; Archives of Environmental Contamination and Toxicology; 26: 473-477 (1994)] only deposition was quantified over 6 separate application events (i.e., one event was not included in deposition calculations "due to negative air stability"). The application parameters were similar to that used by Moore *et al*. A 95 percent formulation of malathion was applied from May to August of 1993. A Leco 1600 ULV cold aerosol generator (Lowndes Engineering Company, Valdosta Georgia) was also used to make each application. The application parameters included a fluid flow rate of 4.3 fluid ounces per minute, a vehicle groundspeed of 10 mph, and a nominal application rate of 0.057 lb ai/acre (i.e., equates to a deposition rate of 0.58 $\mu g/cm^2$). Deposition was monitored at four locations downwind from the treatment area (i.e., 5 m, 25 m, 100 m and 500 m). For the events considered in the deposition calculations, "malathion mass deposited differed significantly between the 500 m site and the three closer sites (df = 3; F-value = 3.42; P<0.05)." The percentage of the application rate reported to have deposited (not including 500 m samples which were much less) ranged up to 5.8 percent. The mean deposition value for all measurements was 3.8 percent.

After considering the data that are available in the Tietze *et al.* and Moore *et al.* papers, an off-target deposition rate of 5 percent of the application rate was used by HED to evaluate ground-based ULV applications (i.e., 5 percent of application rate is the deposition rate of which 1.3 percent is determined from the turf study discussed earlier, to be available for dislodging). A value slightly higher than the mean values for both studies was selected because of the variability in the data and the limited number of data points. It should be noted that this value is also consistent with the draft modeling assessment for ground-ULV approaches completed by S.T. Perry and W.B. Petersen of EPA's Office of Research and Development (i.e., within a factor of 5). Perry and Petersen used "the INPUFF Lagrangian puff model" as the basis for their assessment (Petersen and Lavdas, 1986: *INPUFF 2.0 - A Multiple Source Gaussian Puff Dispersion Algorithm, User's Guide*, EPA/600/8-86/024). Depending on the scenario selected from this document, deposition rates ranged from aproximately 2.5 percent deposition 450 m downwind to 15 to 20 percent deposition **immediately adjacent** to the treatment zone.

Aerial ULV

Data similar to that for ground applications discussed above were not available for the aerial deposition. Therefore, in order to calculate deposition from aerial ULV applications, HED used *AgDRIFT* (V 1.03 -- June 1997) which is the model that was developed as a result of the efforts of the *Spray Drift Task Force (SDTF).* The SDTF is a coalition of 38 pesticide registrants whose primary objectives were to develop a comprehensive database of off-target drift information in support of pesticide registrations and an appropriate model system. This model was selected based on the consensus of several experts in

the spray drift area because it represents the current state-of-the-art. HED discussed the issue of model selection with several experts in the spray drift community prior to selecting *AgDRIFT* (e.g., Sandra L. Bird, U.S. EPA; Steven G. Perry, U.S. EPA; Milton E. Teske, Continuum Dynamics; Pat Skyler, U.S. Forest Service; Arnet Jones, U.S. EPA; and Harold Thistle, U.S. Forest Service). HED considered using the *USDA Forest Service Cramer-Barry-Grim Model* (commonly referred to as *FSCBG*). *FSCBG* was developed through support from the U.S. Forest Service, in cooperation with the U.S. Army, and has been in existence for over 20 years in various iterations. Actual support and development of *FSCBG* was completed by Continuum Dynamics, Inc. located in Princeton, New Jersey under the technical direction of Milton E. Teske. However, it was decided that *AgDRIFT* should be used because it is based on essentially the same algorithms as *FSCBG* (personal communication with Milton E. Teske of Contiuum Dynamics), it has undergone extensive validation by the *SDTF*, and it is very user-friendly compared to *FSCBG*.

*AgDRIFT* is a *Microsoft Windows*-based personal computer program that is provided to the U.S. Environmental Protection Agency's Office of Pesticide Programs as a product of the Cooperative Research and Development Agreement (CRADA) between EPA's Office of Research and Development and the *SDTF*. *AgDRIFT* predicts the motion of spray material released from aircraft, including the mean position of the material and the position variance about the mean as a result of turbulent fluctuations. *AgDRIFT* enhancements include a significant solution speed increase, an in-memory computation of deposition and flux as the solution proceeds, and extensive validation based on 180 separate aerial treatments performed during field trials in 1992 and 1993 by the SDTF.

*AgDRIFT* is capable of producing a variety of useful outputs. The key for HED in this assessment was to determine from the model what percentage of the application volume remained aloft and what percentage of the resulting droplets deposited on the surfaces in the treatment area as well as downwind from the treatment area. *AgDRIFT* is generally intended to calculate deposition rates in areas that are downwind from the treatment area (i.e., presented from the border of the treatment area to areas of interest downwind). HED has used the values at the border of the treatment area to represent the deposition rate within the treated area.

Deposition from aerial ULV applications is assumed to be uniform throughout the drift zone even though *AgDRIFT* indicates minor fluctuations in the region of interest. The deposition region of interest has been defined as the region immediately adjacent to the treatment area out to a reasonable model approximated limit (i.e., for aerial -- about 2000 feet).

The following are important *AgDRIFT* model input parameters used for this risk assessment.

| For aerial ULV mosquito control: | For aerial ULV boll weevil eradication: |
|---|---|
| Droplet size distribution | |
| $D_{v0.1}$ = 29.45 $\mu$m; $D_{v0.5}$ = 56 $\mu$m; $D_{v0.9}$ = 108 $\mu$m; < 141 $\mu$m: 98% | $D_{v0.1}$ = 65 $\mu$m; $D_{v0.5}$ = 110.74 $\mu$m; $D_{v0.9}$ = 179.99 $\mu$m; < 141 $\mu$m: 75.07% |
| Spray material | |

| | |
|---|---|
| Inputs include: nonvolatile rate = 0.24 lb per acre; specific gravity = 1.2; spray rate = 0.05 gal/acre; active ingredient application rate = 0.23 lb ai/acre; and, evaporation rate = 1 $\mu m^2$/deg C/sec). | Inputs include: nonvolatile rate = 2.5 lb per acre; specific gravity = 1.2; spray rate = 0.25 gal/acre; active ingredient application rate = 0.9 lb ai/acre; and, evaporation rate = 1 $\mu m^2$/deg C/sec). |
| Aircraft | |
| User defined option (fixed-wing aircraft). Inputs include: Douglas DC3; wingspan = 94.6 ft; typical application airspeed = 228.1 mph; weight = 21,396 lb.; planform area = 1009.63 $ft^2$; propeller RPM = 2550; propeller radius = 5.81 ft; engine vertical distance = -1.22 ft; and, engine forward distance = 6.1 ft; | User defined option (fixed-wing aircraft). Inputs include: Air Tractor AT-401; wingspan = 49 ft; typical application airspeed = 120 mph; weight = 6000 lb.; planform area = 294 $ft^2$; propeller RPM = 2000; propeller radius = 4.5 ft; engine vertical distance = -1.2 ft; and, engine forward distance = 11.9 ft; |
| Nozzels | |
| User defined option. Inputs include: number of nozzels = 60; vertical distance = -2.66 ft; forward distance = -0.8202 ft; and, horizontal distance limit = 75 %. | User defined option. Inputs include: number of nozzels = 42; vertical distance = -2.66 ft; forward distance = -0.8202 ft; and, horizontal distance limit = 0 %. |
| Meteorology | |
| Windspeed = 2 mph; wind direction = - 90 degrees (perpendicular to flight path); temperature = 86 deg F; and, relative humidity = 90%. | Windspeed = 10 mph; wind direction = - 90 degrees (perpendicular to flight path); temperature = 86 deg F; and, relative humidity = 50%. |
| Control | |
| Release height = 300 ft; number of spray lines = 20 (aircraft passes) in each application event; swath width = 499 ft; and, swath displacement based on aircraft centerline. | Release height = 10 ft; number of spray lines = 20 (aircraft passes) in each application event; swath width = 55 ft; and, swath displacement = 27.5 ft.. |
| Advanced settings | |
| Wind speed height = 2 m; maximum compute time = 600 sec; maximum downwind distance 795 meters; vortex decay rate = 0.56 m/sec; propeller efficiency = 0.8; and ambient pressure = 1013 mb. | Wind speed height = 2 m; maximum compute time = 600 sec; maximum downwind distance 795 meters; vortex decay rate = 0.56 m/sec; propeller efficiency = 0.8; and ambient pressure = 1013 mb. |

For aerial ULV mosquito control, it was determined that in the area of concern (i.e., from the edge of the treatment area to 1000 feet downwind), approximately 35 percent of the theoretical application is deposited. For aerial ULV boll weevil control, it was determined that in the area of concern (i.e., from the edge of the field to 75 feet downwind), approximately 40 percent of the theorectical application is deposited.

After the deposition factors were determined, post application exposure values were calculated using appropriate surrogate exposure values, label stipulated application rates, and application rates based on available use information.

**Assumptions and Surrogate Data**. Residential risks were assessed for both adults and toddlers based on guidance provided in the *Draft: Standard Operating Procedures (SOPs) for Residential Exposure Assessment (12/11/97 Version)*. Additionally, the open literature and the SDTF *AgDRIFT* model was used to assess deposition to residential turf after malaria vector applications of ULV liquids. These efforts were necessary to integrate the unique agricultural engineering aspects of malaria vector control applications into the HED risk assessment. Calculations for both adults and toddlers were completed using the maximum application rates for ground-based and aerial application scenarios.

No proprietary data from the Spray Drift Task Force (SDTF) was used in this assessment. Additionally, AgDRIFT was recently presented before the FIFRA Science Advisory Panel. Modifications

to the model are possible as a result of the SAP comments. These modifications, however, are anticipated by HED not to significantly alter the results of this assessments. Any significant modifications to the model may require further refinement of this assessment. Even given the potential for modification of the model, the assessment is much more refined than assuming 100 percent of the application rate is deposited on the turf in residential areas where aerial ULV applications occur. The latter approach (i.e., 100% deposition) is recognized by HED as completely unrealistic given what is known concerning the engineering aspects of malaria vector control and other aerial ULV applications.

The equations and assumptions used for each of the scenarios were taken from the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document[8]. Interim changes to these SOPs have been adopted by the HED Exposure Science Advisory Council regarding standard values for turf transferrable residues, turf transfer coefficient and hand-to-mouth activities. The new standard values are used throughout this assessment, and are denoted below with (‡). The following general assumptions were made for all scenarios:

- Postapplication was assessed on the same day the pesticide is applied because it was assumed that the homeowner could be exposed to gardens, fruits and nuts, ornamental shrubs, flowers, trees, and turfgrass immediately after application. Therefore, postapplication exposures were based on day 0.

- Adults were assumed to weigh 70. Toddlers (3 years old), used to represent the 1 to 6 year old age group, were assumed to weigh 15 kg.

- The maximum labeled application rate (ULV) for aerial mosquito control is 0.23 lb ai/acre. The maximum labeled application rate (ULV) for ground-based fogger mosquito control is 0.11 lb ai/acre. (based on FYFANON® ULV label. EPA Reg. No. 4787-8)

- The dermal transfer coefficient which is the basis for the toddler calculation is based on a Jazzercise activity which is generally considered to represent a bounding estimate of dermal exposure. Another conservative aspect of the postapplication calculation is the duration in which exposed populations are assumed to be in contact with treated turf on a daily basis (i.e., 2 hours/day for adults and toddlers -- both upper percentile estimates based on data available in the *EPA Exposure Factors Handbook*).

**Dermal exposure (turf, gardens, fruit & nuts, and ornamentals):**

$$ADD = (DFR_t * CF1 * Tc * ET) / BW$$

where:

| | | |
|---|---|---|
| ADD | = | average daily dose (mg/kg/day) |
| $DFR_t$ | = | dislodgeable foliar residue on day "t" ($\mu g/cm^2$) |
| CF1 | = | weight unit conversion factor to convert $\mu$g units in the DFR value to mg for the daily dose (0.001 mg/$\mu$g) |
| Tc | = | transfer coefficient ($cm^2$/hr) |
| ET | = | exposure time (hr/day) |
| BW | = | body weight (kg) |

and

$$DFR_t = AR * F * (1-D)^t * CF2 * CF3$$

where:

AR = application rate (lb ai/sq feet) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers]
F = fraction of ai retained on foliage (0.013, unitless)
D = fraction of residue that dissipates daily (0.46, unitless)
t = postapplication day on which exposure is being assessed (day 0)
CF2 = weight unit conversion factor to convert the lbs ai in the application rate to $\mu$g for the DFR value (4.54E8 $\mu$g/lb)
CF3 = area unit conversion factor to convert the surface area units ($ft^2$) in the application rate to $cm^2$ for the DFR value (2.47E-8 acre/$cm^2$ if the application rate is per acre)

- (‡) The mean dermal transfer coefficient for turf was assumed to be 14,500 $cm^2$/hr for adults and 5,200 $cm^2$/hr for toddlers.

- The mean dermal transfer coefficient for gardens, fruit and nuts, and ornamentals was assumed to be 10,000 $cm^2$/hr for adults.

- The exposure time for toddlers and adults to turf was assumed to be 2 hours per day.

- The exposure time for adults (age 18-64 years) to garden and tree foliage was assumed to be 0.67 hours per day, based on the 95$^{th}$ percentile values for time spent working in a garden or other circumstances working with soil.

**Hand-to-mouth (turf and gardens):**

$$ADD = (DFR_t * SA * FQ * EX * ET * CF1) / BW$$

where:

ADD = average daily dose (mg/kg/day)
$DFR_t$ = dislodgeable foliar residue on day "t" ($\mu$g/$cm^2$ turf)
SA = surface area of the hands ($cm^2$/event)
FQ = frequency of hand-to-mouth activity (events/hr)
ET = exposure time (hr/day)
EX = extraction by saliva
CF1 = weight unit conversion factor to convert $\mu$g units in the DFR value to mg for the daily exposure (0.001 mg/$\mu$g)
BW = body weight (kg)

- (‡) The median surface area of both hands was assumed to be 20 $cm^2$ for a toddler (age 3 years).

- Replenishment of the hands with pesticide residues was assumed to be an implicit factor in this assessment.

- It was assumed that there is a one-to-one relationship between the dislodgeable residues on the turf and on the surface area of the skin after contact (i.e., if the dislodgeable residue on the turf is 1 mg/$cm^2$, then the residue on the human skin is also 1 mg/$cm^2$ after contacting the turf).

- (‡) It was assumed that 50% of the residue on the hand is extracted by saliva.

- (‡) The mean rate of hand-to-mouth activity is 20 events/hr for toddlers (3 to 5 years old).

- The duration of exposure for toddlers was assumed to be 2 hours per day.

**Turfgrass ingestion:**

$$ADD = (GR_t * IgR * CF1) / BW$$

where:

| | | |
|---|---|---|
| ADD | = | average daily dose (mg/kg/day) |
| $GR_t$ | = | grass residue on day "t" ($\mu g/cm^2$) |
| IgR | = | ingestion rate of grass ($cm^2$/day) |
| CF1 | = | weight unit conversion factor to convert the $\mu g$ of residues on the grass to mg to provide units of mg/day (1E-3 mg/$\mu g$) |
| BW | = | body weight (kg) |

and

$$GR_t = AR * F * (1-D)^t * CF2 * CF3$$

where:

| | | |
|---|---|---|
| AR | = | application rate (lb ai/acre) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers] |
| F | = | fraction of ai available on the grass (unitless) |
| D | = | fraction of residue that dissipates daily (unitless) |
| t | = | postapplication day on which exposure is being assessed |
| CF2 | = | weight unit conversion factor to convert the lbs ai in the application rate to $\mu g$ for the grass residue value (4.54E8 $\mu g$/lb) |
| CF3 | = | area unit conversion factor to convert the surface area units ($ft^2$) in the application rate to $cm^2$ for the grass residue value (2.47E-8 acre/$cm^2$ if the application rate is per acre) |

- The assumed ingestion rate for grass for toddlers (age 3 years) was 25 $cm^2$/day (i.e., 2 x 2 inches or 4 $in^2$). This value was intended to represent the approximate area from which a child may grasp a handful of grass.

**Incidental Soil Ingestion (turf and gardens):**

$$ADD = (SR_t * IgR * CF1) / BW$$

where:

| | | |
|---|---|---|
| ADD | = | average daily dose (mg/kg/day) |
| $SR_t$ | = | soil residue on day "t" ($\mu g/g$) |
| IgR | = | ingestion rate of soil (mg/day) |
| CF1 | = | weight unit conversion factor to convert the $\mu g$ of residues on the soil to grams to provide units of mg/day (1E-6 g/$\mu g$) |
| BW | = | body weight (kg) |

and

$$SR_t = AR * F * (1-D)^t * CF2 * CF3 * CF4$$

where:

| | | |
|---|---|---|
| AR | = | application rate (lb ai/acre) [* 35 percent for aerial foggers, and * 5 percent for ground-based foggers] |

F = fraction of ai available in uppermost cm of soil (fraction/cm)
D = fraction of residue that dissipates daily (unitless)
t = postapplication day on which exposure is being assessed
CF2 = weight unit conversion factor to convert the lbs ai in the application rate to $\mu$g for the soil residue value (4.54E8 $\mu$g/lb)
CF3 = area unit conversion factor to convert the surface area units ($ft^2$) in the application rate to $cm^2$ for the SR value (2.47E-8 acre/$cm^2$ if the application rate is per acre)
CF4 = volume to weight unit conversion factor to convert the volume units ($cm^3$) to weight units for the SR value (0.67 $cm^3$/g soil)[7]

- On the day of application, it was assumed that 100 percent of the application rate are located within the soil's uppermost 1 cm.

- The assumed soil ingestion rate for children (ages 1-6 years) was assumed to be 100 mg/day.

**Risk Calculations**

Intermediate-term MOEs were calculated as follows, using the NOAELs for malathion, as described previously:

$$\text{MOE} = \frac{\text{NOEL}}{\text{ADD}}$$

### 3.2.3 Inhalation Exposure and Risk from Aerial ULV and Ground-based Truck Fogger Application for Mosquito Control

As mentioned earlier, inhalation exposure usually does not factor significantly into postapplication risk. However, due to the major use of malathion in ULV aerial and truck fogger applications to control mosquitoes, a risk assessment has been developed below for residential inhalation exposure from aerial ULV and ground-based truck fogger applications. The approach is based on the one described in the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessment for inhalation exposure to outdoor residential short-term pest control. The major difference is that the SOPs begin assuming the use of a commercial fogger product that has a known volume. In the scenario below, the beginning assumption is that the full application rates for aerial ULV and ground-based fogger truck (with the standard SOP value for dilution) is available in the breathing zone of the residential bystander, thus turning an application rate expressed as lbs. ai/$ft^2$, into a concentration expressed in a per cubic foot ($ft^3$) basis. The following is a stepwise process, including assumptions and calculations for estimating residential bystander inhalation exposure to aerial ULV and truck fogger applications in mosquito control.

**Data and Assumptions**

- Aerial ULV application rate is 0.23 lb ai/acre
- Ground-based ULV truck fogger application rate is 0.11 lb ai/acre
- Dilution of airborne concentration of 1 to 100 (i.e., 1 percent (0.01) of product released is available for exposure
- Adult breathing rate = 0.55 $m^3$, and weight is 70 kg; toddler breathing rate = 0.36 $m^3$, and weight is 15 kg
- Exposure time is 20 minutes (0.33 hours)

- Target MOE = 1000
- Short- and intermediate-term Inhalation NOAEL = 25.8 mg/kg/day

**Calculations**

for Aerial ULV:

- Application rate of 0.23 lb ai/acre x 1 acre/43,560 $ft^2$ = 0.0000053 lbs ai/$ft^2$
- Expressed as an airborne concentration = 0.0000053 lbs ai/$ft^3$
  0.0000053 lbs ai/$ft^3$ x 35.3 $ft^3$/1 $m^3$ = 0.00019 lbs ai/$m^3$
  0.00019 lbs ai/$m^3$ x 454,000 mg/lb = 86.26 mg/$m^3$
- Application concentration (86.26 mg/$m^3$) x dilution factor (0.01) = 0.86 mg/$m^3$
- $Dose_{adult}$ = (concentration) x ( breathing $rate_{adult}$) x (exposure duration) ÷ $BW_{adult}$
  = (0.86 mg/$m^3$) x (0.55 $m^3$/hour) x (0.33 hours/day) ÷ 70 kg = 0.002 mg/kg/day

- **Short- and Intermediate-term $Risk_{adult}$ = MOE = $NOAEL_{inhal}$./$Dose_{adult}$**
  **= (25.8 mg/kg/day)/(0.002 mg/kg/day) = 12,900**

- $Dose_{toddler}$ = (concentration) x ( breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$
  = (0.86 mg/$m^3$) x (0.36 $m^3$/hour) x (0.33 hours/day) ÷ 15 kg = 0.0068 mg/kg/day

- **Short- and Intermediate-term $Risk_{toddler}$ = MOE = (25.8 mg/kg/day)/(0.0068 mg/kg/day) = 3800**

Both adult and toddler risk estimates for inhalation exposure do not exceed the level for Agency concern for residential bystander inhalation exposure from aerial ULV mosquito control applications. It is important to note also that the above risks are based on conservative assumptions regarding the circumstances of exposure (i.e., standing for 20 minutes in an air concentration that is not considered to dissipate and for which ground deposition estimates of only 35% of the application rate have not been factored in). These inhalation risks are aggregated with dermal risks from the same exposure scenario in a later section.

for ULV Truck-fogger

- Application rate of 0.11 lb ai/acre x 1 acre/43,560 $ft^2$ = 0.0000025 lbs ai/$ft^2$
- Expressed as an airborne concentration = 0.0000025 lbs ai/$ft^3$
  0.0000025 lbs ai/$ft^3$ x 35.3 $ft^3$/1 $m^3$ = 0.000088 lbs ai/$m^3$
  0.000088 lbs ai/$m^3$ x 454,000 mg/lb = 39.95 mg/$m^3$
- Application concentration (39.95 mg/$m^3$) x dilution factor (0.01) = 0.4 mg/$m^3$
- $Dose_{adult}$ = (concentration) x ( breathing $rate_{adult}$) x (exposure duration) ÷ $BW_{adult}$
  = (0.4 mg/$m^3$) x (0.55 $m^3$/hour) x (0.33 hours/day) ÷ 70 kg = 0.001 mg/kg/day

- **Short- and Intermediate-term $Risk_{adult}$ = MOE = $NOAEL_{inhal}$./$Dose_{adult}$**
  **= (25.8 mg/kg/day)/(0.001 mg/kg/day) = 25,800**

- $Dose_{toddler}$ = (concentration) x ( breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$
  = (0.4 mg/$m^3$) x (0.36 $m^3$/hour) x (0.33 hours/day) ÷ 15 kg = 0.003 mg/kg/day

- **Short- and Intermediate-term $Risk_{toddler}$ = MOE = (25.8 mg/kg/day)/(0.003 mg/kg/day) = 8600**

Both adult and toddler risk estimates for inhalation exposure do not exceed the level for Agency concern for inhalation exposure to truck foggers. It is important to note also that the above risks are based on

conservative assumptions regarding the circumstances of exposure (i.e., standing for 20 minutes in the direct off-loading of a fogger truck as it passes by, without consideration of dissipation or depostion rate estimates). These inhalation risks are aggregated with dermal risks from the same exposure scenario in a later section.

### 3.2.4 Non-Occupational Postapplication Exposure Risk Estimates

The results of the residential postapplication exposure/risk assessment are presented in Table 16.

**Table 16: Short- and Intermediate-Term Residential Post-application Scenarios and Estimated Risks for Malathion**

| Scenario | Crop or Target | Receptor | Application Rate Per Treatment (AR) (lbs ai/sq ft)[a] | DFR ($ug/cm^2$)[b] | Grt ($ug/cm^2$)[c] | Srt (ug/g)[d] | Transfer Coefficient (Tc) ($cm^2$/hr) | Exposure Time (ET) (hrs/day) | Dermal Abs. (%) | Surface Area (SA) ($cm^2$/ event) | Freq. (FQ) (events/ hr) | IgR ($cm^2$/day) or (mg/day)[e] | BW (kg) | ADD (mg/kg/day)[f] | MOE[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dermal exposure | Turf (handgun - by commercial applicator) | Adult | 0.00019 | 1.2 | - | - | 14,500 | 2 | 100 | - | - | - | 70 | 0.50 | 100 |
| | | Toddler | | | | | 5,200 | | | | | | 15 | 0.83 | 60 |
| | Turf (handgun - by residential applicator) | Adult | 0.00018 | 1.1 | - | - | 14,500 | 2 | 100 | - | - | - | 70 | 0.47 | 110 |
| | | Toddler | | | | | 5,200 | | | | | | 15 | 0.79 | 63 |
| | Turf (air ULV) | Adult | 0.0000053 | 0.012 | - | - | 14,500 | 2 | 100 | - | - | - | 70 | 0.005 | 10000 |
| | | Toddler | | | | | 5,200 | | | | | | 15 | 0.01 | 6300 |
| | Turf (grnd ULV) | Adult | 0.0000025 | 0.0008 | - | - | 14,500 | 2 | 100 | - | - | - | 70 | 0.00033 | 150000 |
| | | Toddler | | | | | 5,200 | | | | | | 15 | 0.00055 | 90000 |
| | Vegetable/Small Fruit Gardens | Adult | 0.000115 | 11.2 | - | - | 10,000 | 0.67 | 100 | - | - | - | 70 | 1.07 | 47 |
| | "Pick-your-own" strawberries | Adult | 0.000115 | 11.2 | | | 10,000 | 1 | 100 | | | | 70 | 1.6 | 31 |
| | Fruit Trees & Ornamentals | Adult | 0.000085 | 8.3 | - | - | 10,000 | 0.67 | 100 | - | - | - | 70 | 0.79 | 63 |
| Hand-to-Mouth | Turf (handgun) | Toddler | 0.00019 | 1.2 | - | - | - | 2 | 50 extraction | 20 | 20 | - | 15 | 0.032 | 1600 |
| | Turf (air ULV) | | 0.0000053 | 0.012 | | | | | | | | | | 0.0003 | 160000 |
| | Turf (grnd ULV) | | 0.0000025 | 0.00080 | | | | | | | | | | 0.00002 | 2.5E+6 |
| | Vegetable/ Small Fruit Gardens | Toddler | 0.000115 | 11.2 | - | - | - | 2 | 50 extraction | 20 | 20 | - | 15 | 0.3 | 170 |
| Turfgrass ingestion | Turf (handgun) | Toddler | 0.00019 | - | 1.2 | - | - | - | - | - | - | 25 | 15 | 0.002 | 25000 |
| | Turf (air ULV) | | 0.0000053 | | 0.012 | | | | | | | | | 2.0E-5 | 2.5E+6 |
| | Turf (grnd ULV) | | 0.0000025 | | 0.008 | | | | | | | | | 1.3E-5 | 3.8E+6 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Incidental soil ingestion | Turf (handgun) | Toddler | 0.00019 | - | - | 62 | - | - | - | - | - | 100 | 15 | 0.0004 | 125000 |
| | Turf (air ULV) | | 0.0000053 | | | 0.6 | | | | | | | | 4.0E-6 | 1.3E+7 |
| | Turf (grnd ULV) | | 0.0000025 | | | 0.04 | | | | | | | | 3.0E-7 | 1.7E+8 |
| | Vegetable/ Small Fruit Gardens | Toddler | 0.000115 | - | - | 38 | - | - | - | - | - | 100 | 15 | 0.0003 | 170000 |

a Application rates are estimated as follows: turf(handgun) - 0.18 lb ai per 1,000 sq. ft.; turf (air ULV) - (0.23 lb ai/A)/43,560 sq. ft. per A; turf (ground ULV) - (0.11 lb ai/A)/43,560 sq. ft. per A; vegetable/small fruit gardens- (0.023 lb ai/gal * 5 gallons)/1,000 $ft^2$; fruit trees and ornamentals-(0.034 lb ai/gal * 5 gal)/2,000 $ft^2$.

b Dislodgeable foliar residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) * fraction ai retained on foliage (1.3% [* 0.35 for air ULV, or * 0.05 for ground ULV]) * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$].

c Grass residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) * fraction ai retained on foliage (1.3% [* 0.35 for air ULV, or * 0.05 for ground ULV] ) * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$].

d Soil residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) [* 0.35 for air ULV, or * 0.05 for ground ULV] * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$ * 0.67 $cm^3$/g soil].

e Ingestion rate: $cm^2$/day for grass ingestion, and mg/day for incidental soil ingestion.

f Average daily dose (ADD) (mg/kg/day)

Dermal exposure: = [DFR ($ug/cm^2$) * Tc ($cm^2$/hr) * mg/1,000 ug * ET ( hrs/day) * absorption factor (1.0)] / [BW (kg)];
Hand-to-mouth: = [DFR ($ug/cm^2$) * SA ($cm^2$/event) * FQ (events/hr) * mg/1,000 ug * Saliva extraction (50%) * ET (hrs/day)] / [BW (kg)];
Turfgrass ingestion: = [GRt ($ug/cm^2$) * IgR ($cm^2$/day) * mg/1,000 ug] / [BW (kg)]; and
Incidental soil ingestion: = [SRt (ug/g) * IgR (mg/day) * g/1,000,000 ug] / [BW (kg)].

g MOE = NOEL (50 mg/kg/day) / ADD.

### 3.2.5 Summary of Non-occupational Postapplication Risks, Data Gaps, and Confidence in Exposure and Risk Estimates

The surrogate assessment was based on the turf study discussed under section 2.2.4 above. Transfer coefficients used are believed to be the best currently available for the assessment of malathion postapplication exposure potential.

**Postapplication Risk Estimates**

The resulting surrogate residential postapplication assessment indicates that the following scenarios do not reach the target MOE (i.e., the MOEs are < 100) for short- and intermediate-term exposures from reentry:

- Dermal exposure to residues on turf following application with handgun sprayer by commercial and residential applicators (toddler);

- Dermal exposure to residues on vegetables/small fruit gardens, fruit trees, and ornamentals following homeowner spray applications (adult) and in "pick-your-own" strawberries (adult)

All other scenarios exceed the target MOE.

## 3.3 Non-occupational Aggregate Exposures and Risks

Under the Food Quality Protection Act (FQPA), various exposure scenarios that could result in multiple non-occupational exposures to a particular pesticide must be aggregated. A realistic exposure assessment under this FQPA requirement would aggregate exposure only from activities that would reasonably be expected to occur on the same day. The assessment is done separately for adults and toddlers. For adults, aggregate exposure must consider the potential for both handling/applying the pesticide, as well as, the potential postapplication contact. For toddlers, only postapplication is relevant, however, certain age specific differences, like hand-to-mouth activity and body weight must be considered here, as well. Aggregate assessment for malathion is addressed in a another section of the RED document.

Table 18. below shows the combined inhalation and dermal exposure estimates for adults and toddlers following aerial ULV and ground ULV Public Health mosquito control treatment.

**Table 18: Non-occupational Combined Postapplication Inhalation and Dermal Risk**

| Scenario | Application Rate | Crop Type or Target | Dermal Daily Dose (mg/kg/day) | Dermal MOE (UF=100) | Inhalation Daily Dose (mg/kg/day) | Inhal. MOE (UF=1000) | Total Aggregate Risk Index (ARI) |
|---|---|---|---|---|---|---|---|
| Adult | | | | | | | |
| (1) Postapplication Inhalation and Dermal Contact with Turf Following **Ground ULV** Truck Fogger Application | 0.0000025 (lb ai/sq ft) | Public Mosquito Control | 0.00033 | 150,000 | 0.001 | 26,000 | 25 |
| (2) Postapplication Inhalation and Dermal Contact with Turf Following **Aerial ULV** Application. | 0.0000053 (lb ai/sq ft) | Public Mosquito Control | 0.005 | 10,000 | 0.002 | 13,000 | 12 |
| Toddler | | | | | | | |
| (1) Postapplication Inhalation and Dermal Contact with Turf Following **Ground ULV** Application | 0.0000025 (lb ai/sq ft) | Public Mosquito Control | 0.00055 | 90,000 | 0.003 | 8600 | 8 |
| (2) Postapplication Inhalation and Dermal Contact with Turf Following **Aerial ULV** Application | 0.0000053 (lb ai/sq ft) | Public Mosquito Control | 0.01 | 6300 | 0.0068 | 3800 | 3.6 |

## 3.4 Special Assessment for the USDA Boll Weevil Eradication Program

### 3.4.1 Executive Summary

The Boll Weevil Eradication Program (BWEP) is a special project under the direction of the United States Department of Agriculture. This program is unique in that it attempts to systematically eradicate the boll weevil pest in cotton-growing regions of the US. This comprehensive and systemiatic approach was considered to be sufficiently different from normal agricultural use of malathion on cotton, specifically, or in agriculture, in general, that it was decided to address the exposure and risk from the BWEP, separately in the sections to follow.

For the USDA Boll Weevil Eradication Program, malathion is applied to cotton using ultra low volume (ULV) techniques (95% ai), at a maximum rate of 0.9 lb active ingredient per acre, primarily by fixed-wing aircraft. Exposure to malathion from boll weevil treatment may occur to occupational handlers, to post-application workers who enter treated fields, and to non-occupational bystanders (represented primarily by individuals living in close proximity to treated fields). Risks to the above individuals were estimated by comparing potential exposures against appropriate toxicity endpoints for the routes and durations of exposure anticipated. HED concern for an individual's risk is not triggered if: (1) the dermal MOE is > 100;(2) the inhalation MOE is > 1000; and (3) the aggregate risk index (ARI) for dermal and inhalation exposure is $\geq$ 1. The findings are summarized below.

Occupational handler exposures do not trigger HED concern if certain mitigation measures are employed:

- Mixers/loaders: ARI = 1.5 with full PPE; ARI = 3, if using closed mixing/loading systems;

- Applicators: ARI = 5 with closed cockpit aircraft;

- Flaggers: ARI = 2.3 with baseline clothing;

Occupational post-application exposures do not trigger HED concern at the Worker Protection Standard Restricted Entry Interval (REI) of 12 hours for both harvesting and non-harvesting activities.

Non-occupational (bystander) exposures do not trigger HED concern:

- Dermal exposure from contact with residues from aerial spray drift: adult MOE = 2300; toddler MOE = 1400;

- Incidental ingestion from hand-to-mouth activity (turf): toddler MOE = 36,000;

- Incidental ingestion from eating turfgrass: toddler MOE = 600,000;

- Incidental ingestion from eating soil: toddler MOE = 3.0E+6;

- Inhalation exposure: adult MOE = 7600; toddler MOE = 2600;

- Combined dermal exposure from contact with residues from aerial spray drift and inhalation: adult ARI = 5; toddler ARI = 2;

Monitoring data collected by the USDA Animal and Plant Health Inspection Service (APHIS) also show levels of exposure to be relatively low in sites adjacent to spraying in accordance with the USDA Boll Weevil Eradication Program. For example, in the USDA Environmental Monitoring Report - 1995 Southeast Boll Weevil Eradication Program, all personal breathing zone samples were < 0.001 $mg/m^3$ . This, when compared to the air concentration predicted by the HED assessment (1.32 $mg/m^3$)

indicates that the HED assessment includes assumptions that lead to estimates of exposure that are higher than are being found in some actual boll weevil treatment sites.

### 3.4.2 Exposure Assessment

#### 3.4.2.1 Use Pattern[9]

The boll weevil eradication program utilizes malathion fomulated as a 95% ultra low volume (ULV) concentrate, applied primarily by fixed-wing aircraft (98%), with the remaining acres treated by high-cycle ground equipment, mist blowers, and helicopters. Label application rates range from 0.3 to 1.5 lb ai/acre[10]. Typical application rates are reported to be 10 to 12 fluid onces per acre (or 0.7 to 0.9 lb ai/A using Fyfanon® ULV[10]). Malathion applications begin at the pinhead square crop phenology and end at the defoliation stage, or if a killing freeze occurs. Typical length of the program is four years. The number of applications is 6-10 in the first year; 4-6 in the second year; 1-2 in the third year; and minimal in the fourth year. Application are made at intervals of 7 - 10 days.

#### 3.4.2.2 Non-Dietary Exposure

Occupational and non-occupational (residential) exposure to malathion and malaoxon residues via dermal and inhalation routes can occur during handling, mixing, loading, and applying activities. Postapplication exposure potentials also exist. There is potential dermal exposure to persons entering treated sites (occupational and non-occupational) following application of malathion-containing products. This includes the potential for dermal and inhalation exposure to individuals (bystanders) at home or in public areas following nearby aerial applications for boll weevil eradication.

Based on toxicological criteria and potential for exposure, HED has conducted dermal and inhalation exposure assessments for the occupational handler and postapplication dermal exposure assessments for occupational workers. HED has also conducted dermal and inhalation exposure assessments for residential settings, including postapplication dermal and inadvertent oral ingestion exposure to adults and/or children from potential spray drift during cotton treatment for boll weevil eradication.

#### 3.4.2.3 Occupational Handler Exposure Scenarios

HED has identified 3 major scenarios that account for most of the exposure potential for occupational handlers using malathion to control the boll weevil: (1) mixing/loading ULV liquids for aerial application; (2) applying ULV sprays with a fixed-wing aircraft, and; (3) flagging for ULV aerial spray application. The scenarios were classified as being short- and intermediate-term in duration (covering one day to several months). A long term exposure duration (i.e., continuous exposure of $\geq$180 days) is not expected because malathion use for boll weevil treatment is only during the cotton seasonal growth cycle.

Because application to control the boll weevil is predominantly accomplished by fixed-wing aircraft (approximately 98%), only handler scenarios involving this equipment are assessed in this document. Handler exposure scenarios for the other equipment for treating the boll weevil have been adequately covered by the scenarios (under ULV ag crops) evaluated in HED's, "Malathion: Preliminary Risk Assessment for the Reregistration Eligibility Decision (RED) Document. November 8, 1999," and all resulted in meeting or exceeding the target MOE (some with the need for PPE or engineering controls).

The estimated exposures considered for this assessment were baseline protection (long pants and a long-sleeved shirt, no gloves, and an open cab or tractor), and additional personal protective equipment (PPE, which includes a double layer of clothing and gloves and/or a dust/mist respirator), or engineering controls (closed mixing/loading systems for liquids and enclosed cabs/trucks), where needed to achieve the target Margins of Exposure (MOEs).

#### 3.4.2.4 Occupational Handler Exposure Data Sources and Assumptions

Chemical specific data for assessing human exposures during pesticide handling activities were not submitted to the Agency in support of the reregistration of malathion. Therefore, data from the HED Pesticide Handlers Exposure Database (PHED) Version 1.1 was used.

The following assumptions and factors were used to complete this exposure assessment:

- Average body weight of an adult handler is 70 kg. This body weight is used in both the short- and intermediate-term assessment, since the endpoint of concern is not sex-specific (i.e., the cholinesterase inhibition could be assumed to occur in males or females).

- Average work day interval represents an 8 hour workday (e.g., the acres treated or volume of spray solution prepared in a typical day).

- Daily acres and volumes (as appropriate) to be treated in each scenario include:

  -- 1200 acres of cotton per day for ULV aerial applications

- Calculations are completed for the maximum (0.9 lb ai/A) from the range of application rates for the boll weevil eradication program, as identified by the U.S. Department of Agriculture (USDA)[9].

- The maximum number of days that an individual may apply malathion in years one and two of the program is approximately 70 days in a period of six months[9].

- When scenario-specific data are not available, HED calculates unit exposure values using generic protection factors that are applied to represent the use of personal protective equipment (PPE) and engineering controls.

#### 3.4.2.5 Occupational Handler Risk Characterization

This assessment of the BWEP uses the same toxicity endpoints , approach and equations that were used earlier to assess other agricultural uses of malathion. Refer to those sections for details.

A detailed summary of the short-term and intermediate-term risk estimates for baseline, additional PPE, and engineering controls is presented in Table 19.

**Table 19: Occupational Handler Short-term and Intermediate-term Risks from Malathion at Baseline, with Additional PPE, and with Engineering Controls.**

| Exposure Scenario (Scenario #) | Crop Type or Target | Baseline | | | Personal Protective Equipment (PPE)[a] | | | Engineering Controls | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dermal MOE[b] (UF=100) | Inhalation MOE[c] (UF=1000) | Total Risk Index (ARI) [d] | Dermal MOE[b] (UF=100) | Inhalation MOE[c] (UF=1000) | Total Risk index (ARI) [d] | Dermal MOE[b] (UF=100) | Inhalation MOE[c] (UF=1000) | Total Risk Index (ARI) [d] |
| Mixer/Loader Exposure | | | | | | | | | | |
| Mixing/Loading ULV Liquids for Aerial Application (1) | cotton | 140 (GO) | 1400 | 0.7 | 190 | 7000 | 1.5 | 380 (GO) | 20,000 | 3 |
| Applicator Exposure | | | | | | | | | | |
| Applying ULV Sprays with a Fixed-Wing Aircraft (2) | cotton | See Engineering controls | | | | | | 630 | 26,000 | 5 |
| Flagger Exposure | | | | | | | | | | |
| Flagging for ULV Aerial Spray Applications (3) | cotton | 400 | 5200 | 2.3 | - | - | - | - | - | - |

**Footnotes:**

[a] Personal Protective Equipment: Except where noted [GO = Gloves Only; NR = No Respirator], additional PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator.

[b] Dermal MOE (short- and intermediate-term) = NOAEL (50 mg/kg/day)/Daily Dermal Dose (mg/kg/day).

[c] Inhalation MOE(short- and intermediate-term) = LOAEL (25.8 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

[d] Total ARI (short- and Intermediate-term) = 1 / ((1/Calculated Dermal MOE/Target Dermal MOE (100)) + (1 /Calculated Inhalation MOE/Target Inhalation MOE (1000))).

The **baseline** calculations indicate that the total ARIs are greater than, or equal to 1 and are **NOT** of risk concern for the following scenario:

- (3) flagging for aerial ULV applications (ARI=2.3)

The **personal protective equipment (PPE)** calculations for the scenarios requiring additional exposure reduction, indicate that the total ARIs are greater than, or equal to 1 and are **NOT** of risk concern for the following scenario:

- (1) mixing/loading liquids for aerial application (ARI=1.5).

PPE means double layer of clothing, chemical resistant gloves, and dust/mist respirator.

The **engineering control** calculations for scenarios requiring additional exposure reduction, indicate that the total ARIs are greater than, or equal to 1 with additional **engineering controls** for the following scenario:

- (2) applying ULV sprays with a fixed-wing aircraft (ARI= 5)

### 3.4.2.6 Occupational Postapplication Exposures and Risks

EPA has determined that there are potential intermediate-term occupational postapplication exposures to individuals entering treated fields and contacting malathion and malaoxon residues on plant surfaces. Only postapplication dermal exposure has been assessed because postapplication inhalation exposure is expected to be negligible. Workers are expected, generally, to be performing activities (harvesting or non-harvesting) in malathion-treated fields for at least seven or more consecutive workdays in a growing season, with some fields receiving repeat malathion applications at 7-10 day intervals. Because of the seasonal nature of malathion use, a long-term exposure scenario is not expected for field workers.

### 3.4.2.7 Postapplication Exposure Scenarios

The scenarios likely to result in postapplication exposure are as follows:

- Non-harvesting activities that have potential for a low degree of dermal contact (i.e., scouting) Tc = 1000 $cm^2$/hour
- Harvesting activities that have potential for a high degree of dermal contact (i.e., transferring cotton from harvester into bulk container and stomping) Tc = 10,000 $cm^2$/hour

Current labels include a 12 hour restricted entry interval (REI).

### 3.4.2.8 Data Sources and Assumptions for Postapplication Exposure

The postapplication exposure assessment for the BWEP used the same data (i.e., data from a turf transferable residue study - MRID 44113301), approach and equations as were used in the assessments for other agricultural uses of malathion. Refer to these previous sections for details.

### 3.4.2.9 Postapplication Occupational Risk Characterization

Postapplication Risk Estimates: Both non-harvesting and harvesting activities resulted in MOEs > 100 on the same day as treatment, and therefore, do not trigger HED's concern.

A summary of the postapplication worker risks appears in Table 20. The estimates were made using the following assumptions:

- Assumed percent DFR following initial treatment is 20%
- Predicted percent dissipation per day is 46%
- Hours worked per day is 8
- Transfer coefficient for scouting is 1000; for hand-labor associated with harvesting, Tc = 10,000

| Table 20. Summary of Malathion Occupational Post-Application Exposure and Risk Estimates | | | | |
|---|---|---|---|---|
| Crops | Application Rate (lb ai/acre) | REI where MOE ≥ 100 (MOE value) | | Current REI[2] |
| | | Non-harvesting[1] | Harvesting[1] | |
| Cotton | 0.9 | **same day** (2200) | **same day** (200) | 12 hours |

1 Default transfer coefficients were used for the above categories according to HED Science Advisory Council Policy.003 (May 7, 1998).
* Primary non-harvesting activit is scouting (Tc= 1000)
* Harvesting (Tc= 10,000) It is important to note that for cotton, which is mechanically harvested, negligible exposure is considered likely, except for any ancillary manual activities associated with the process. These latter activities , such as collecting cotton from the harvester and stomping in bulk container, must be considered in the exposure assessment.

2 Set as interim REIs based on the criteria of the Agency's Worker Protection Standards.

### 3.4.3 Residential Handler Exposure

Malathion is a common home/garden use product. Residential handler exposure to malathion residues via dermal and inhalation routes can occur during handling, mixing, loading, and applying activities. Assessment of these exposures is covered in earlier sections of this document.

#### 3.4.3.1 Residential Postapplication Exposures and Risks

HED has determined that there is potential for non-occupational postapplication exposures to malathion residues from the following sources spray drift from the use of malathion on cotton in the USDA Boll Weevil Eradication Program.

This assessment considers the potential for inhalation (adults and children), dermal contact with residues on residential turf (adults and children), and incidental oral ingestion (children only) of malathion residues on residential turf and soil, following application of nearby cotton fields with malathion.

These potential exposures are estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) aerial applications in the vicinity of residential dwellings. The assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in other recreational areas (e.g., school playgrounds, parks, athletic fields).

HED believes it is reasonable to expect dermal, inhalation, and inadvertent oral exposure from this application to occur in a single day. The risks for both short- and intermediate-term toxicity has been assessed.

#### 3.4.3.2 Postapplication Exposure Scenarios

The scenarios likely to result in dermal and inhalation(adult and child), and incidental non-dietary (child) postapplication exposures resulting from boll weevil control uses are as follows:

- Dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- Incidental nondietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- Ingestion of treated turfgrass (toddler); and
- Incidental ingestion of soil from treated areas (toddler).
- Inhalation from airborne spray drift;

#### 3.4.3.3 Data Sources and Assumptions for Residential Postapplication Exposure

Residential exposures were assessed for both adults and toddlers based on guidance provided in the *Draft: Standard Operating Procedures (SOPs) for Residential Exposure Assessment (12/11/97 Version)*. Additionally, foliar dissipation data submitted in support of reregistration and modeled estimates of deposition using *AgDRIFT* (V. 1.03 -- June 1997 developed by the *Spray Drift Task Force (SDTF))* were utilized to generate postapplication exposure estimates. Human exposure and deposition monitoring data from published USDA sources were summarized to further characterize the risk.. Refer to previous sections on Data Sources and Assumptions for Residential Postapplication Exposure for more details.

The equations and assumptions used for each of the scenarios were taken primarily from the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document. Chemical-specific data for the use of malathion in the boll weevil eradication program are available from the USDA. These data are discussed in a later section and serve to further characterize the risk determined by the use of models below.

Airborne Exposure Models - Aerial ULV

In order to calculate deposition from aerial ULV applications, HED used *AgDRIFT* (V 1.03 -- June 1997). AgDRIFT is capable of producing a variety of useful outputs. The key for HED in this assessment was to determine from the model what percentage of the application volume remained aloft and what percentage of the resulting droplets deposited on the surfaces in the treatment area as well as downwind from the treatment area. It was determined that from the edge of the treatment area to 75 feet downwind, approximately **40 percent of the theoretical application is deposited**. Thus, the amount of residue on turf resulting from aerial ULV application and available for dermal transfer is estimated as follows:

amount available for transfer = amount deposited x amount dislodgeable (1.3%), where
amount deposited = application rate x deposition rate (40%).

After the deposition factors were determined, postapplication exposure values were calculated using appropriate surrogate exposure values, and application rate based on available use information.

The following additional general assumptions were made for all scenarios:

- Dermal exposure to residues on turfgrass following treatment of nearby cotton fields is considered to be the worst-case scenario for use in assessing residential dermal postapplication risk from the Boll Weevil Eradication Program.
- Postapplication was assessed on the same day the pesticide is applied because it was assumed that the homeowner could be exposed to turfgrass immediately after application. Therefore, postapplication exposures were based on day 0.
- Adults were assumed to weigh 70 kg. Toddlers (3 years old), used to represent the 1 to 6 year old age group, were assumed to weigh 15 kg.
- The maximum application rate (ULV) for aerial boll weevil control is 0.9 lb ai/acre.
- The transfer coefficient which is the basis for thedermal calculation is based on a Jazzercise activity which is generally considered to represent a bounding estimate of dermal exposure. Another conservative aspect of the postapplication calculation is the duration in which exposed populations are assumed to be in contact with treated turf on a daily basis (i.e., 2 hours/day for adults and toddlers).

Additional parameters that effect residue transfers from surface-to-skin, skin-to-mouth, and object-to-mouth activities for adults and/or children are as follows:

*Surface-to-skin residue transfer (adult and toddler)*
Residue source: turf exposure time = 2 hours per day; TC = 14,500 cm2/hr (adult) and 5,200 cm2/hr (toddler)

*Skin-to-mouth residue transfer (toddler)*
residue source: plant surface residue transfer to the hand and to the mouth
The palmar surface area of 3 fingers was assumed to be 20 cm2 for a toddler (age 3 years); replenishment of the hand with pesticide residues was assumed to be an implicit factor; it was assumed that there is a 50% extraction by saliva.

residue source: soil particles transfer from the hand to the mouth
On the day of application, it was assumed that 100% of the application rate is available in the uppermost 1 cm of soil; the assumed ingestion rate for children ages 1-6 is 100 mg/day

*Object-to-mouth residue transfer (toddler)*
residue source: grass surface
The assumed ingestion rate for grass for toddlers (age 3 years) was 25 cm2/day. This value is intended to represent the approximate area from which a child may grasp a handful of grass.

### 3.4.3.4 Residential Postapplication Risk Characterization

The detailed results of the residential postapplication exposure/risk assessment for short-/intermediate-term endpoints are presented in the following sections . Dermal MOEs are above 100 for all scenarios, and combined dermal and inhalation risks for applicable scenarios are all above 1, and do not trigger HED concern for postapplication residential (bystander) exposure in areas nearby fields being treated for boll weevil.

### 3.4.3.5 Postapplication Risk from Dermal Contact and Incidental Ingestion

The following tables show assumptions, calculations and results for the assessment of dermal contact to adults and children with residues on turf, and incidental ingestion by toddlers of residues on grass and soil following aerial ULV treatment of cotton for boll weevil in a nearby field.

## Table 21: Residential Short- and Intermediate-Term Postapplication Scenarios and Estimated Risks for Malathion

| Scenario | Crop or Target | Receptor | Application Rate Per Treatment (AR) (lbs ai/sq ft)[a] | DFR ($ug/cm^2$)[b] | Grt ($ug/cm^2$)[c] | Srt (ug/g)[d] | Transfer Coefficient (Tc) ($cm^2$/hr) | Exposure Time (ET) (hrs/day) | Dermal Abs. (%) | Surface Area (SA) ($cm^2$/ event) | Freq. (FQ) (events/ hr) | IgR ($cm^2$/day) or (mg/day)[e] | BW (kg) | ADD (mg/kg/day)[f] | MOE[g] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dermal exposure | Turf (from aerial ULV spray-drift) | Adult | 0.000021 | 0.054 | - | - | 14,500 | 2 | 100 | - | - | - | 70 | 0.022 | 2300 |
| | | Toddler | | | | | 5,200 | | | | | | 15 | 0.037 | 1400 |
| Hand-to-Mouth | Turf (from aerial ULV spray-drift) | Toddler | 0.000021 | 0.054 | | - | - | 2 | - | 20 | 20 | - | 15 | 0.0014 | 36000 |
| Turfgrass ingestion | Turf (from aerial ULV spray-drift) | Toddler | 0.000021 | - | 0.054 | - | - | - | - | - | - | 25 | 15 | 9.0e-05 | 600,000 |
| Incidental soil ingestion | Turf (from aerial ULV spray-drift) | Toddler | 0.000021 | - | - | 2.76 | - | - | - | - | - | 100 | 15 | 1.8e-05 | 3.0E+6 |

**Footnotes:**

a Application rate: (air ULV) 0.9 lb ai/A)/43,560 sq. ft. per A

b Dislodgeable foliar residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) * fraction ai retained on foliage (1.3% [* 0.40 for air ULV) * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$].

c Grass residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) * fraction ai retained on foliage (1.3% [* 0.40 for air ULV) * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$].

d Soil residue ($ug/cm^2$) = [AR (lbs ai/$ft^2$) [* 0.40 for air ULV] * 4.54E+8 ug/lb * 1.08E-3 $ft^2/cm^2$ * 0.67 $cm^3$/g soil].

e Ingestion rate: $cm^2$/day for grass ingestion, and mg/day for incidental soil ingestion.

f Average daily dose (ADD) (mg/kg/day)

Dermal exposure: = [DFR ($ug/cm^2$) * Tc ($cm^2$/hr) * mg/1,000 ug * ET ( hrs/day) * absorption factor (1.0)] / [BW (kg)];
Hand-to-mouth: = [DFR ($ug/cm^2$) * SA ($cm^2$/event) * FQ (events/hr) * mg/1,000 ug * ET (hrs/day) ] * 0.5 (saliva extraction) / [BW (kg)];
Turfgrass ingestion: = [GRt ($ug/cm^2$) * IgR ($cm^2$/day) * mg/1,000 ug] / [BW (kg)]; and
Incidental soil ingestion: = [SRt (ug/g) * IgR (mg/day) * g/1,000,000 ug] / [BW (kg)].

g MOE = NOAEL (50 mg/kg/day) / ADD.

### 3.4.3.6 Postapplication Risk from Inhalation

The approach is based on the one described in the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessment for inhalation exposure to outdoor residential short-term pest control. The major difference is that the SOPs begin by assuming the use of a commercial fogger product that has a known volume. In the scenario below, the beginning assumption is that the percent of the aerial ULV application rate predicted by the AgDrift Model to be deposited (as above for dermal exposure estimates) is available in the breathing zone of the residential bystander. Thus the deposition rate expressed as lbs. ai/$ft^2$, (to which a dilution factor is applied per Draft Residential SOPs) is now considered to be a concentration expressed on a per cubic foot ($ft^3$) basis. The following is a stepwise process, including assumptions and calculations for estimating residential bystander inhalation exposure from aerial ULV treatment of the boll weevil.

The following inputs, assumptions, and calculations were used to estimate inhalation exposure and risk resulting from aerial ULV applications to treat boll weevils:

**Inputs and Assumptions**

- Aerial ULV application rate is 0.9 lb ai/acre
- Deposition rate over distance of 75 feet beyond edge of treated field = 40% of application rate
- Dilution of airborne concentration of 1 to 100 (i.e., 1 percent (0.01) of product released is available for exposure
- Adult breathing rate = 0.55 $m^3$/hour, and weight is 70 kg; toddler breathing rate = 0.36 $m^3$/hour, and weight is 15 kg
- Exposure time is 20 minutes (0.33 hours)
- Target MOE = 1000
- Short- and intermediate-term Inhalation LOAEL = 25.8 mg/kg/day

**Calculations for short- and intermediate-term risk**

- Application rate of 0.9 lb ai/acre x 1 acre/43,560 $ft^2$ = 0.00002 lbs ai/$ft^2$
- Deposition rate = ~ 40% of application rate at 75 feet from edge of treated field = 0.0000083 lbs ai/$ft^2$
- Expressed as an airborne concentration = 0.0000083 lbs ai/$ft^3$
  0.0000083 lbs ai/$ft^3$ x 35.3 $ft^3$/1 $m^3$ = 0.00029 lbs ai/$m^3$
  0.00029 lbs ai/$m^3$ x 454,000 mg/lb = 131.66 mg/$m^3$
- Application concentration (131.66 mg/$m^3$) x dilution factor (0.01) = 1.32 mg/$m^3$
- $Dose_{adult}$ = (concentration) x ( breathing $rate_{adult}$) x (exposure duration) ÷ $BW_{adult}$
  = (1.32 mg/$m^3$) x (0.55 $m^3$/hour) x (0.33 hours/day) ÷ 70 kg = 0.0034 mg/kg/day

- **Short- and Intermediate-term $Risk_{adult}$ = MOE = $LOAEL_{inhal}$./$Dose_{adult}$ = (25.8 mg/kg/day)/(0.0034 mg/kg/day) = 7600**

- $Dose_{toddler}$ = (concentration) x ( breathing $rate_{toddler}$) x (exposure duration) ÷ $BW_{toddler}$
  = (1.32 mg/$m^3$) x (0.36 $m^3$/hour) x (0.33 hours/day) ÷ 15 kg = 0.010 mg/kg/day

- **Short- and Intermediate-term $Risk_{toddler}$ = MOE = (25.8 mg/kg/day)/(0.010 mg/kg/day) = 2600**

### 3.4.3.7 Non-occupational Combined Exposure/Risk

In Table 22 below, the risks from inhalation of malathion during treatment of a nearby field are added to the risk from dermal contact with residues on turfgrass. This combination of exposures is believed to be the most likely, worst-case scenario. Reasonable upper bound assumptions are included in the estimate, including that the area of concern is only 75 feet from the treated field; that the bystander is standing in the area for 20 minutes during active spraying; that the bystanders are engaged in high-contact activities on the turf for 2 hours on the day of spraying.

**Table 22. Combined Postapplication Inhalation and Dermal Risk Following Boll Weevil Treatment**

| Scenario | Application Rate | Crop Type or Target | Dermal Daily Dose (mg/kg/day) | Dermal MOE (UF=100) | Inhalation Daily Dose (mg/kg/day) | Inhal. MOE (UF=1000) | Total Aggregate Risk Index (ARI) |
|---|---|---|---|---|---|---|---|
| Adult | | | | | | | |
| Postapplication Inhalation and Dermal Contact with Turf Following Aerial ULV Boll Weevil Treatment | 0.000021 (lb ai/sq ft) | Cotton Boll Weevil Eradication | 0.022 | 2300 | 0.0034 | 7600 | 5 |
| Toddler | | | | | | | |
| Postapplication Inhalation and Dermal Contact with Turf Following Aerial ULV Boll Weevil Treatment | 0.000021 (lb ai/sq ft) | Cotton Boll Weevil Eradication | 0.037 | 1400 | 0.010 | 2600 | 2 |

### 3.4.3.7 Residential Postapplication Monitoring Data

Several environmental monitoring studies were conducted by the USDA Animal and Plant Health Inspection Service (APHIS) to assess the potential for human exposure to aerially applied malathion from the USDA Boll Weevil Eradication Program.

**In a 1995 report on the Southeast Boll Weevil Eradication Program[12]**, data were collected on the dermal and inhalation exposure on two different days at two residential houses when nearby cotton fields were treated aerially by malathion. The houses were 3 miles apart; one was 150 feet away from the edge of the treated field; the other 75 feet away. Both downwind and upwind conditions were captured. A roto-rod air sampler was placed 25 feet from the houses to quantitatively measure airborne droplets of malathion in the size range of 10 to 100 microns in diameter. Other air sampling devices with a glass fiber filters and air sampling pumps were placed both inside and outside windows of the houses. Individuals observing the aerial application were fitted with 4x4 gauze pads on their chest, upper arms and legs and with personal air sampling devices to assess dermal and inhalation exposure, respectively. Baseline and 48-hour postapplication blood samples were collected and analyzed for plasma and red blood cell acetylcholinesterase (AChE) levels. These individuals were considered to be part of the worker population, and not residential bystanders.

The above monitoring study found that almost all air samples taken in and around residential houses were below the limit of detection (i.e., <5.0 nanograms for the roto-rods, and <2.42E-6 mg/m$^3$ for the glass fiber filters). Only the roto-rod instrument detected malathion; the largest concentration being seen in the first hour following treatment at one house, on one day (0.02 mg/m$^3$). All personal breathing zone samples were below the limit of detection (i.e., <0.001 mg/m$^3$). Gauze pad data indicated the highest dermal exposure to be 1.56 mg/m$^2$. For all monitored individuals, there were no changes in either plasma or red blood cell AChE levels.

**In a 1998 Environmental Monitoring Report on the Boll Weevil Eradication Program in Alabama, Arkansas, Lousiana, Mississippi, and Tennessee[13]**, the possibility of human exposure to spray drift following aerial application of malathion near sensitive sites, such as residences, public buildings, and schools, was monitored. To do this, three pairs of dye cards were placed between residences, churches, schools, etc., all within 500 feet of the treated cotton field. Cards were placed 30 minutes prior to spraying and were left exposed during treatment and for two hours thereafter. Dye cards with visible spots were sent to the APHIS National Monitoring and Residue Analysis Laboratory for residue analysis. Negative controls were prepared, but positive or spiked controls were not. In all, dye card monitoring was done near 31 sensitive sites during a total of 80 aerial applications. Some sites were monitored for as many as 9 Program-applied treatments. No visible spots were present on 36 of the 80 applications (possibly due to wind direction away from sensitive sites). Of the dye cards on which drops were visible, the measured, residue levels ranged from below the limit of detecction (<0.3 mg/m$^2$) to 30 mg/m$^2$, with the median value of 3.5 mg/m$^2$ and the mean of 5.1 mg/m$^2$. The median and mean values represent 2-4% and 4-6% depositon rates, respectively. Only 13% of the droplet spectra for ULV malathion as applied by the BWEP is in the respirable size range of 1-100 microns (Mierzejewski and Hewitt, 1993).

Dermal exposure and changes in blood AChE levels in agricultural workers, were monitored by fitting four employees of the Program with gauze patches during five full work days and collecting blood samples on a periodic basis (baseline, through

the treatment program season, and two to three weeks following the last treatment of the program). No changes were seen in AChE levels in any of the workers monitored.

**In a 1998 Environmental Monitoring Report on the Boll Weevil Eradication Program in Texas[14],** dye cards and monitoring of AChE levels in workers were used as in the above studies to determine potential exposure to sensitive areas nearby to aerial boll weevil control operations. There were 223 fields near sensitive sites which were sprayed a total of 1,147 times, ranging from 1 to 18 times (average of 5.1 sprays per field). On 30 occasions, visible spotting occurred. Quantitative analysis of cards with visible spotting was not conducted, but most were qualitatively described as having very few or very light spotting. On average, changes in cholinesterase levels (both above and below baseline) were less than 8.5%, with nearly all individuals within 20% of baseline.

### 3.4.3.8 Occupational Exposure Data for OPPTS Guidelines

Additional foliar dislodgeable residue data for crops other than turf are needed to further refine the risk estimates for restricted entry intervals (REIs) for malathion.

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14) Environmental Monitoring Report - 1998 Texas Boll Weevil Eradication Program. United States Department of Agriculture, Animal and Plant Health Inspection Service. Prepared by Technical and Scientific Services.


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